The Case for 3D Cuneiform

2nd Heidelberg Computational Humanities HCH19
July 15 2019

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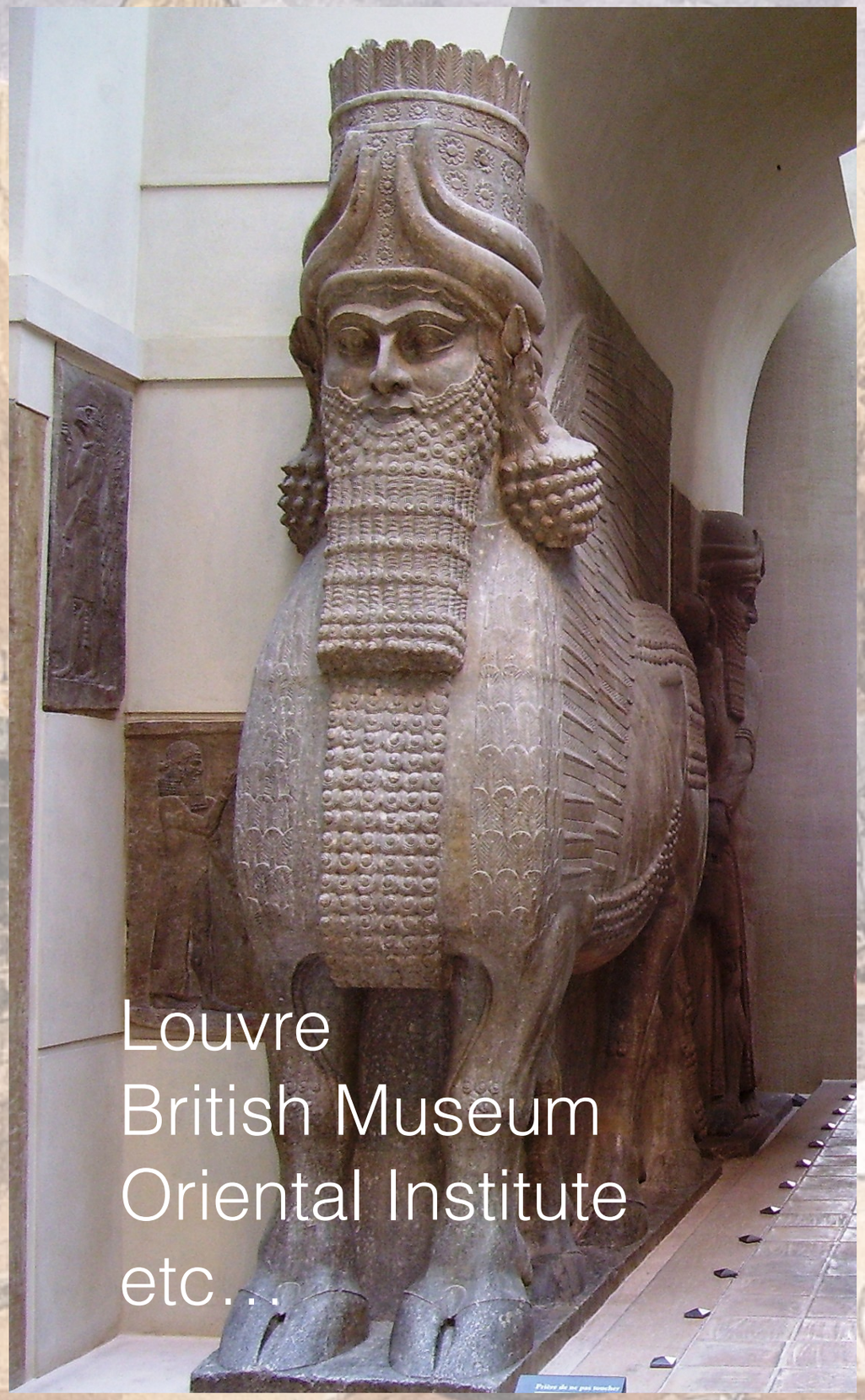
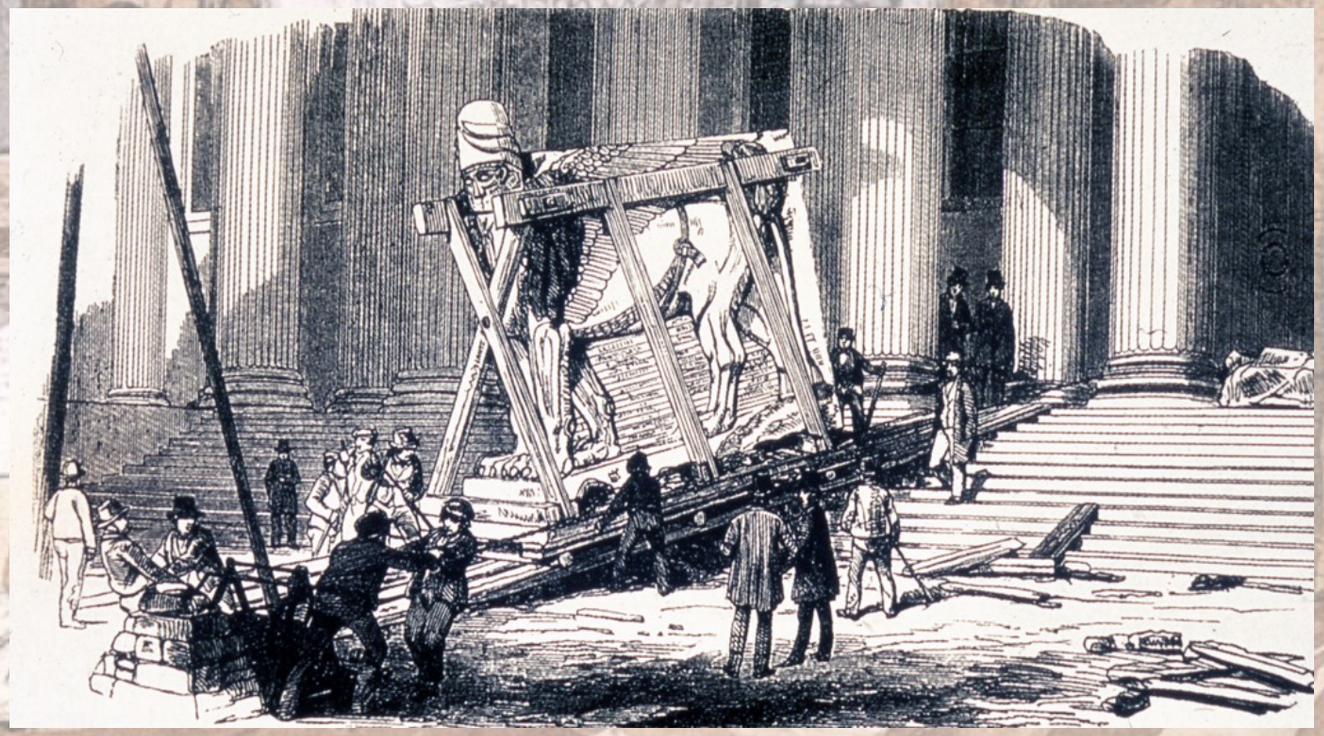


Louvre
British Museum
Oriental Institute
etc…



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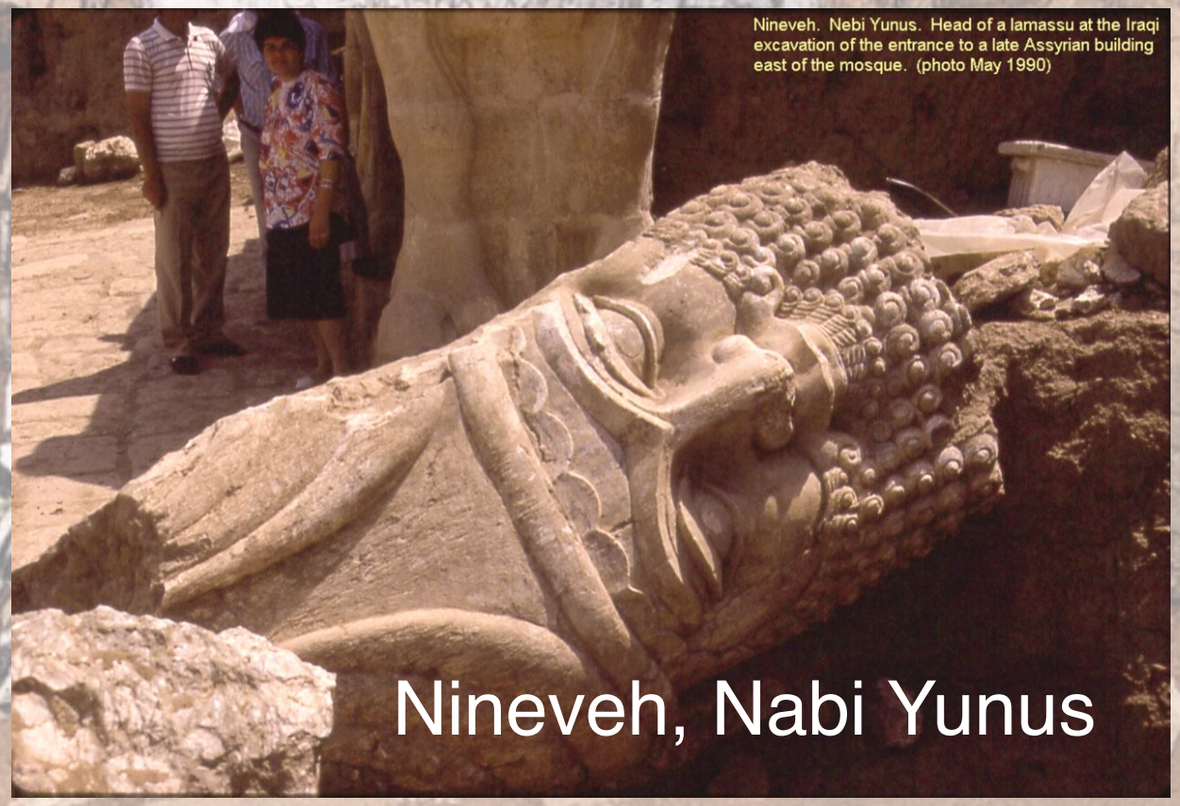

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"Hobby Lobby arranged to purchase thousands of antiquities — including cuneiform tablets and bricks, clay bullae and cylinder seals — for $1.6 million. Some artifacts from the UAE bore shipping labels that falsely described them as "ceramic tiles" or "clay tiles (sample)" NPR, May 2018

Hobby Lobby, Steve Green

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Isin (Ishan Bahriyat, Iraq)

Iraqi looters in the archaeological site of Isin, May 21, 2003. Source: U.S. Department of Defense, Wikimedia Commons.

How Much Money is ISIS Making from Antiquities Looting?

JANUARY 12, 2016

ISIS Revenue Sources in Wilayah al-Kheir, Dec. 23, 2014-Jan. 22, 2015

	Value:	Percentage of Total:
Oil and Gas	$2,335,000	27.7%
Electricity	$331,000	3.9%
Taxes	$1,998,000	23.7%
Confiscations	$3,774,000	44.7%

https://gatesofnineveh.wordpress.com/2016/01/12/how-much-money-is-isis-making-from-antiquities-looting/

Nimrud tomb hoard

Kültepe tablet hoard

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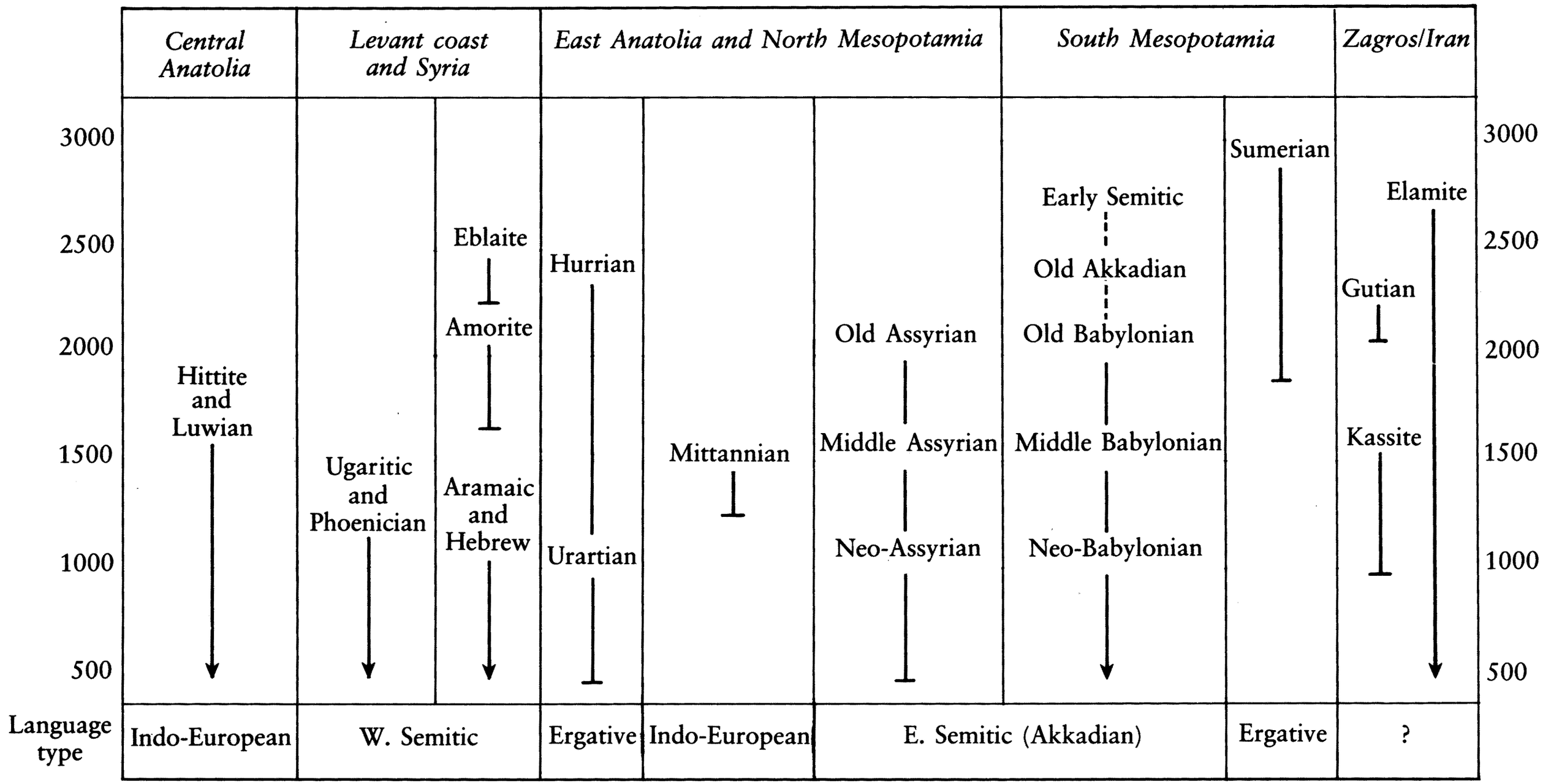

⊥ not known to have survived after this time
↓ survived after this time
| descended from or related to

Figure 2:9 Chart of the principal languages of the ancient Near East with their geographical base and genetic relationships.

Pedersen. 1998. The Archives and Libraries in the ANE 1500-300 BC.

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The main limitation is the human element, with more than 500,000 tablets in museums, and likely another 500,000 in the antiquities markets and private collections, and only ca. 500 experts working with the tablets around the world…

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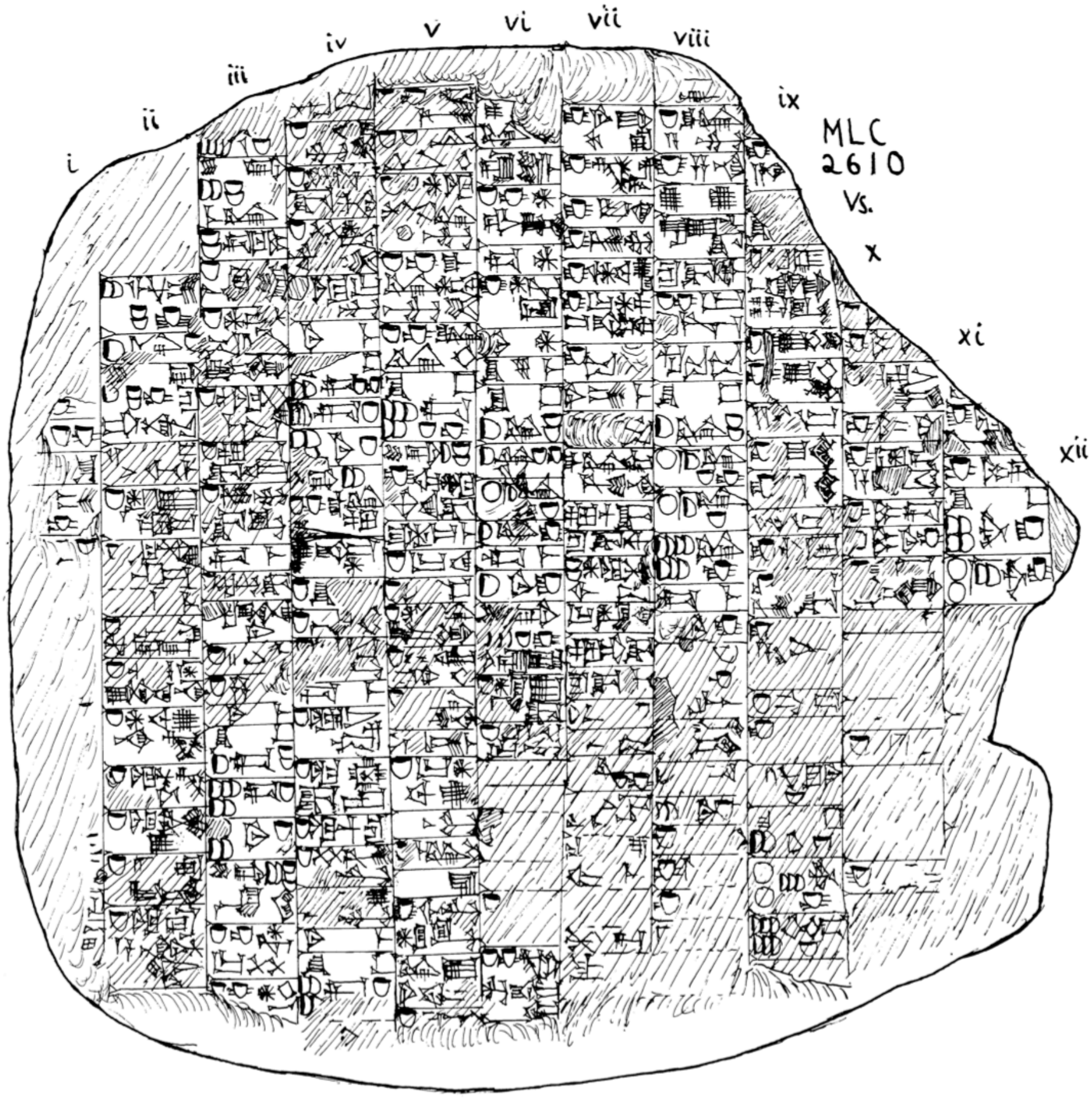
NR. 123 VS.



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http://cdli.ucla.edu/

http://oracc.museum.upenn.edu

obverse

column 1

1. [8(asz@c) igi-nu-du8 1(barig@c) 2(ban2@c)]
2. [sze-bi 2(asz@c) 2(barig@c) 4(ban2@c) gur sag+gal2]
3. [dingir-a-mu]
4. [8(asz@c) igi-nu-du8 1(barig@c)] 2(ban2@c)
5. [1(asz@c) du3-a-ku5] 1(barig@c) 2(ban2@c)
6. [sze-bi 3(asz@c) e2]-ku4#
7. [7(asz@c)? igi-nu]-du8 [1(barig@c)] 2(ban2@c)
8. [1(asz@c) du3-a-ku5 1(barig@c)]
9. [sze-bi 2(asz@c) 2(barig@c) 2(ban2@c) e-ta-e11]
10. [7(asz@c) igi-nu-du8 1(barig@c) 2(ban2@c)]
11. [1(asz@c) du3-a-ku5 1(barig@c) 2(ban2@c)]
12. [1(asz@c) du3-a-ku5 1(barig@c)]
13. [sze-bi 3(asz@c) la2 2(ban2@c) ur-ki]
14. [5(asz@c) igi-nu-du8 1(barig@c) 2(ban2@c)]
15. [1(asz@c) du3-a-ku5] 1(barig@c)#
16. [sze-bi 2(asz@c)] la2# 2(ban2@c) [en-kisal]-si
17. [igi-nu-du8] gesz-me

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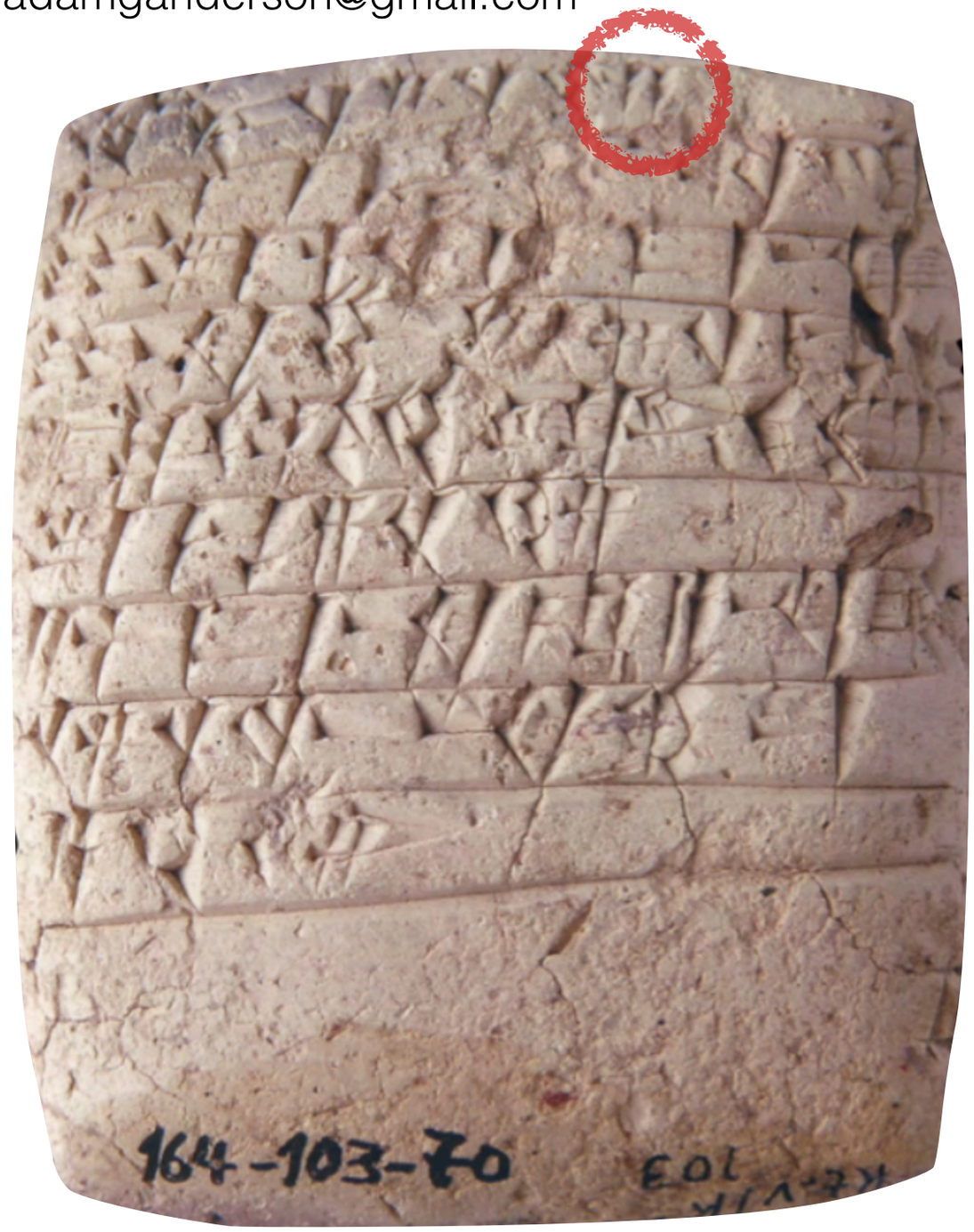

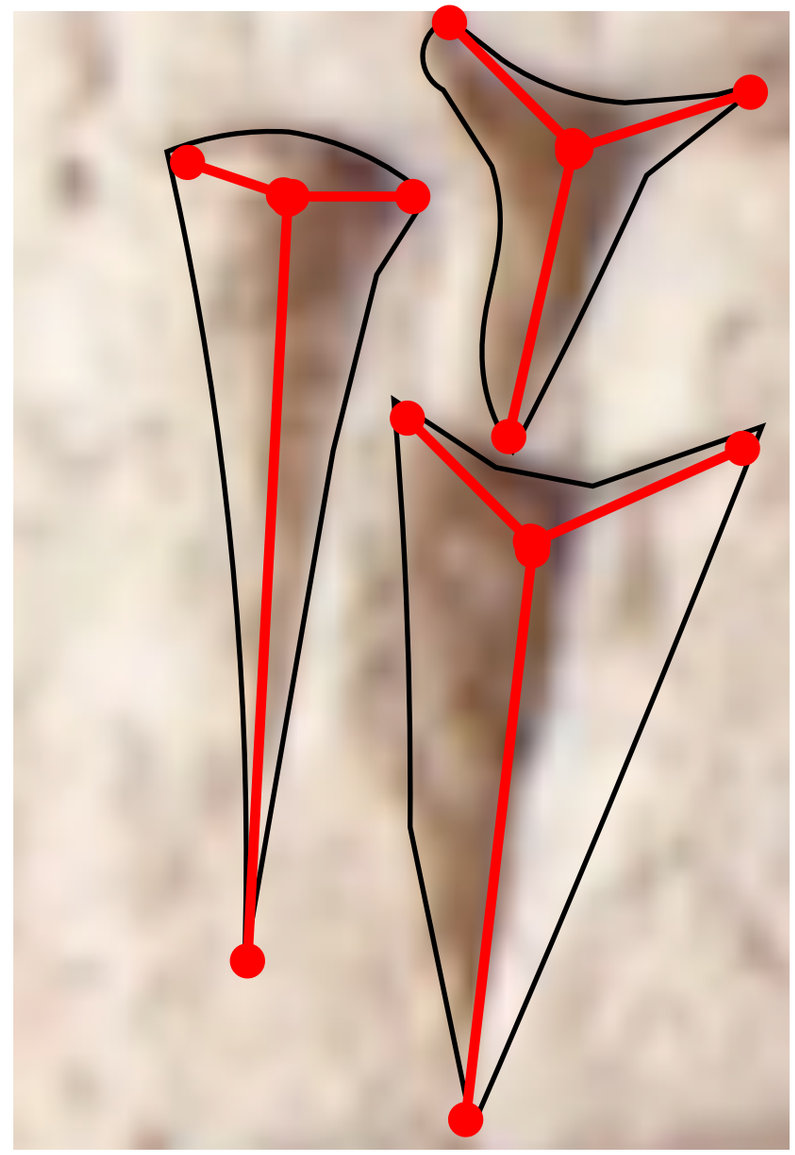

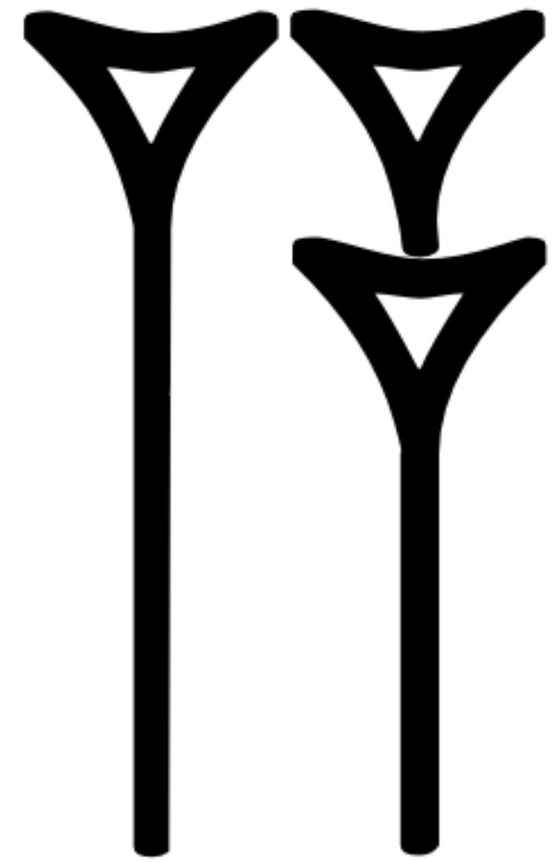

U+12000

Unfortunately, despite the fact that 2D images of tablets are readily available, the photos do not have enough depth to allow for accurate vectorization of the glyphs. So in order to accommodate for the cuneiform regional dialects and hand written glyphs, most scholars continue to draw their copies by hand.

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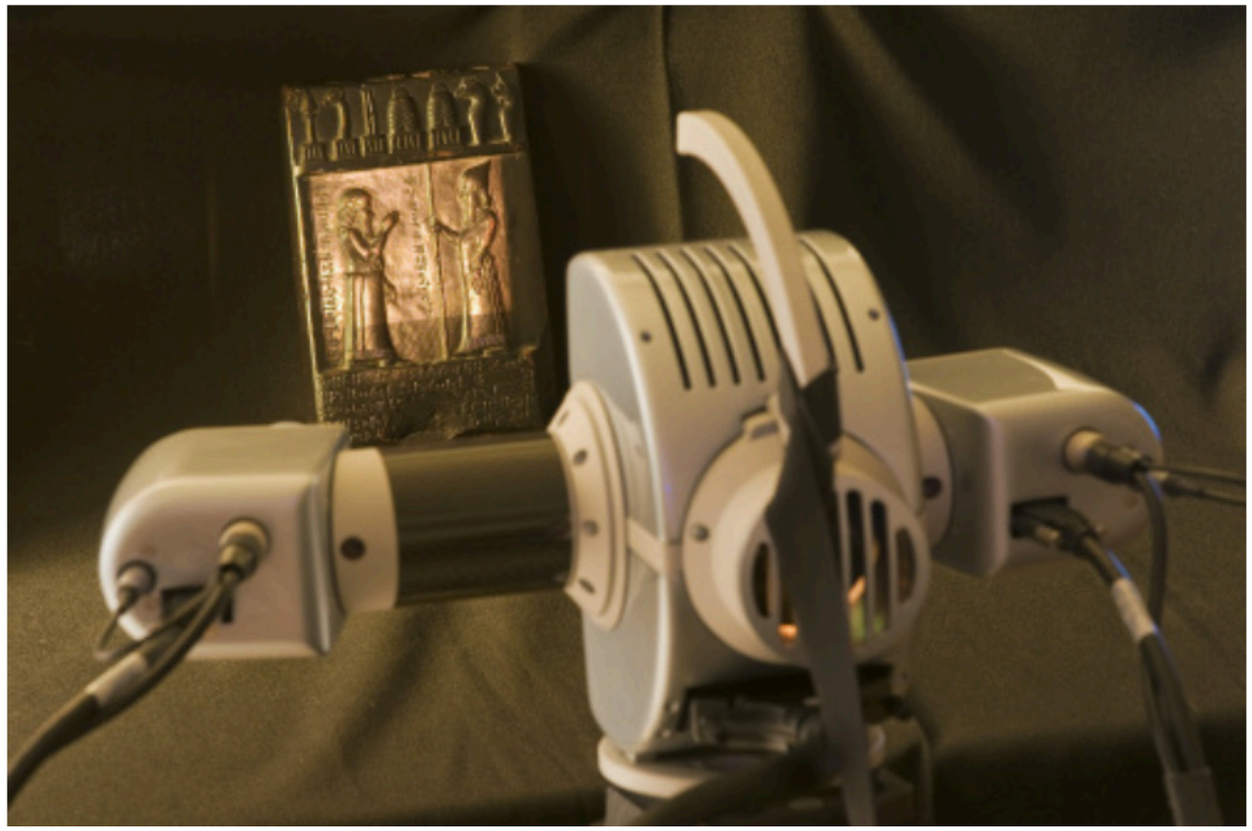
Hubert Mara 2012-2019
Heidelberg University

GigaMesh
3D Scanning
Software Framework



(a) (b) (c)

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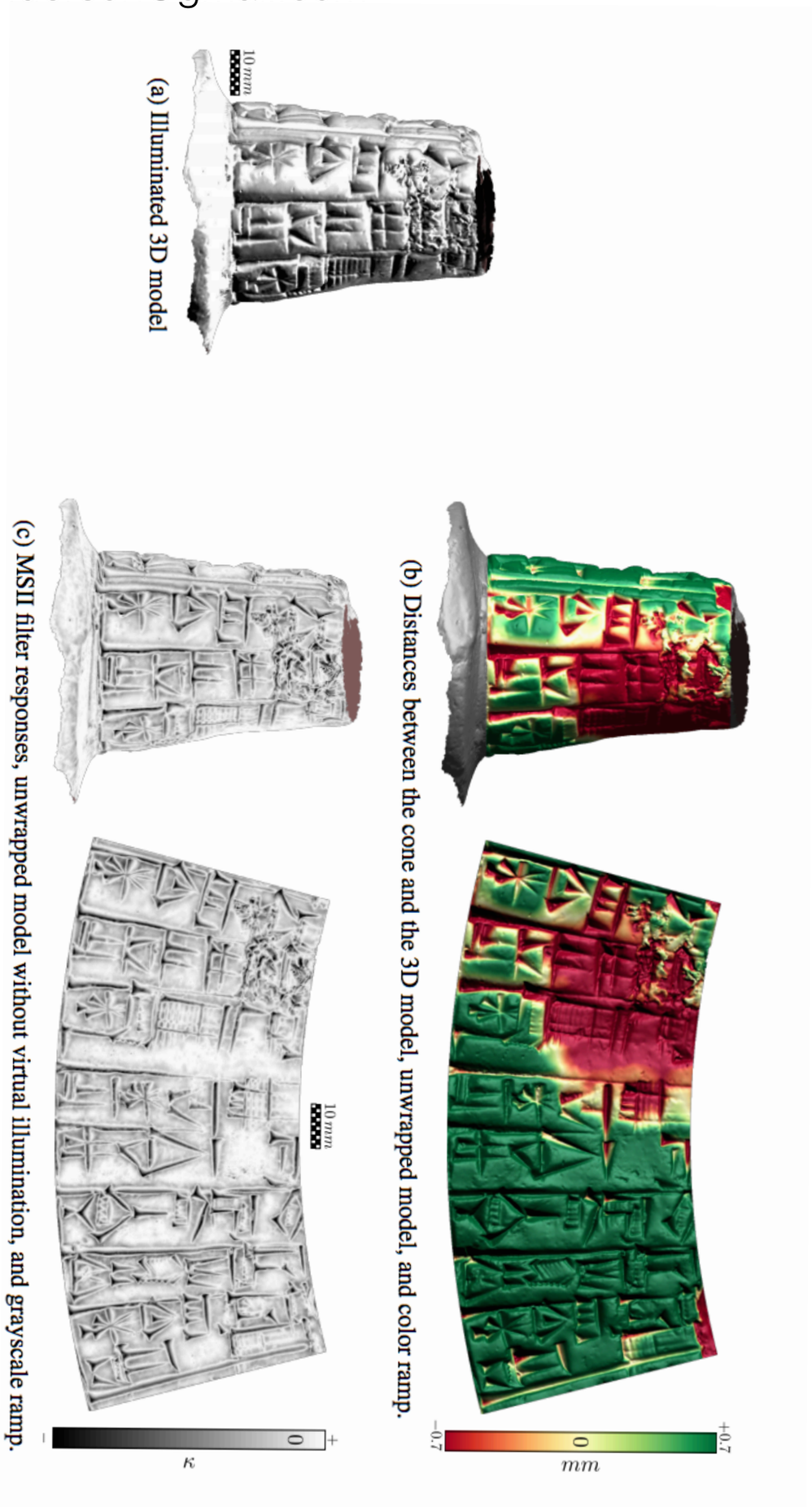

(a) Illuminated 3D model

(b) Distances between the cone and the 3D model, unwrapped model, and color ramp.

(c) MSII filter responses, unwrapped model without virtual illumination, and grayscale ramp.

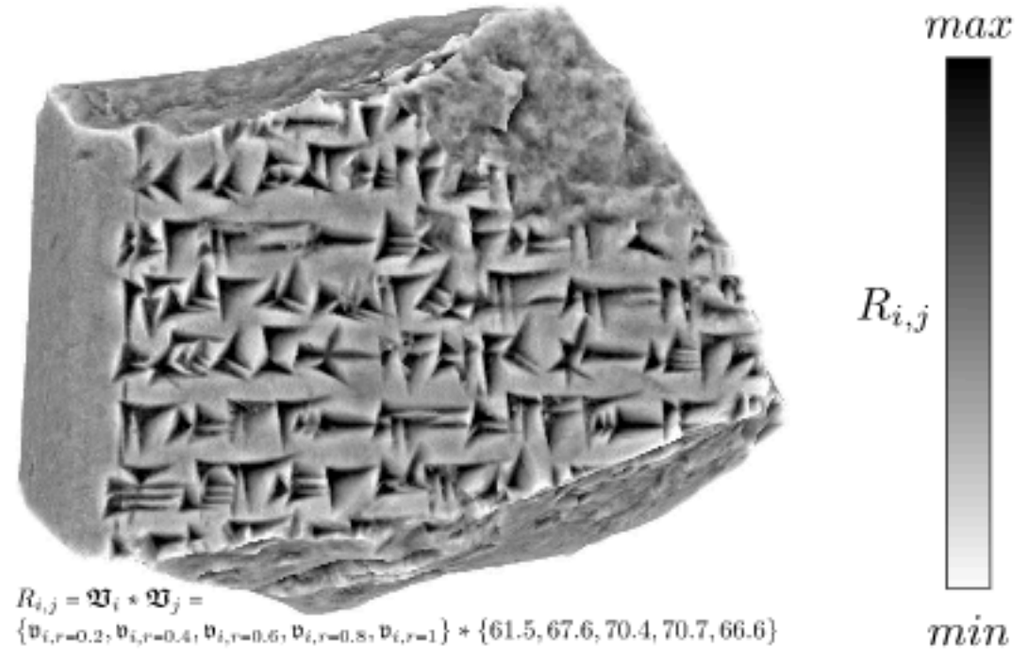

Fig. 3. 3D-model without illumination using the correlation with a reference vector mapped to a gray-scale.

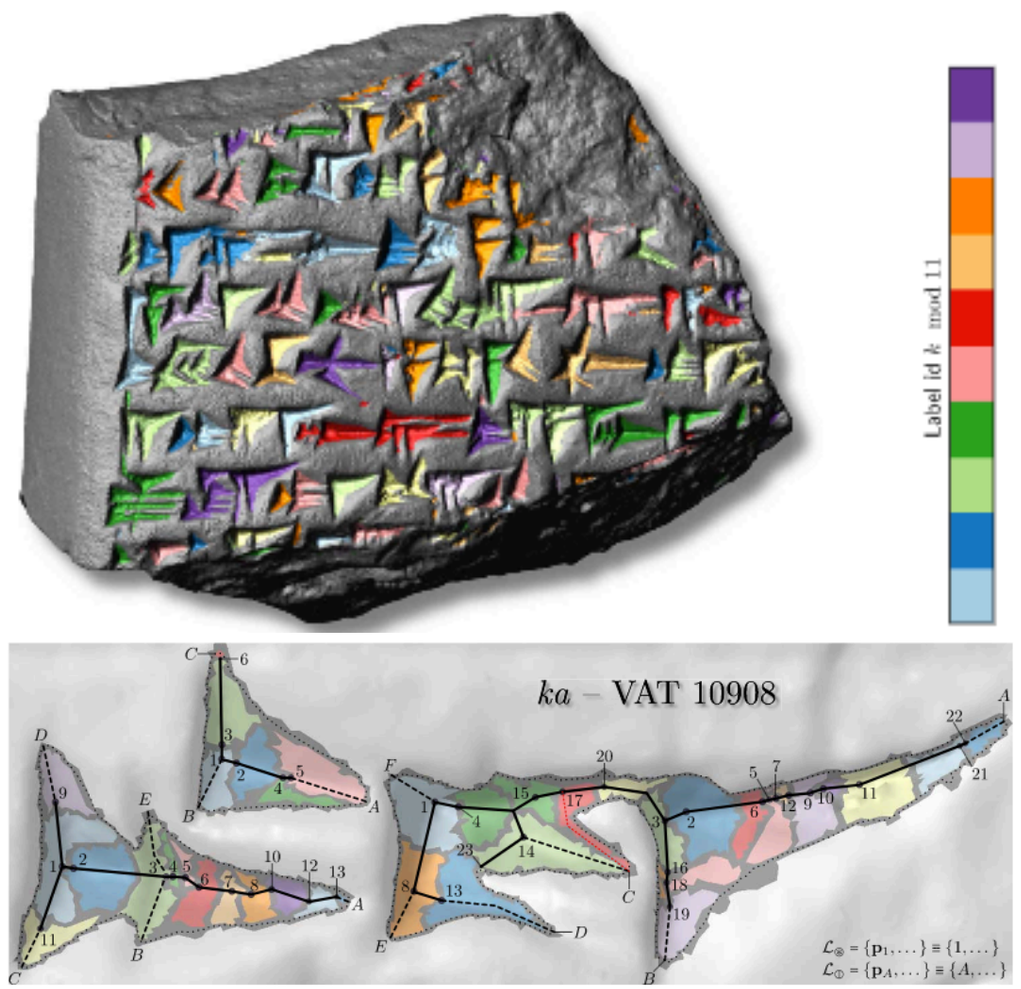

Fig. 6. Robust skeletonization and Voronoi tessellation of the cuneiform character *ka* on a 3D-model of a tablet of the collection of the ancient Near East of the museums in Berlin, Germany. $\mathcal{L}_{\circledast}$ are the points of interest corresponding to the central points of wedges acting as seeds. The points of $\mathcal{L}_{\textcircled{1}}$ are along the wedges outlines and the end nodes of the skeletons.

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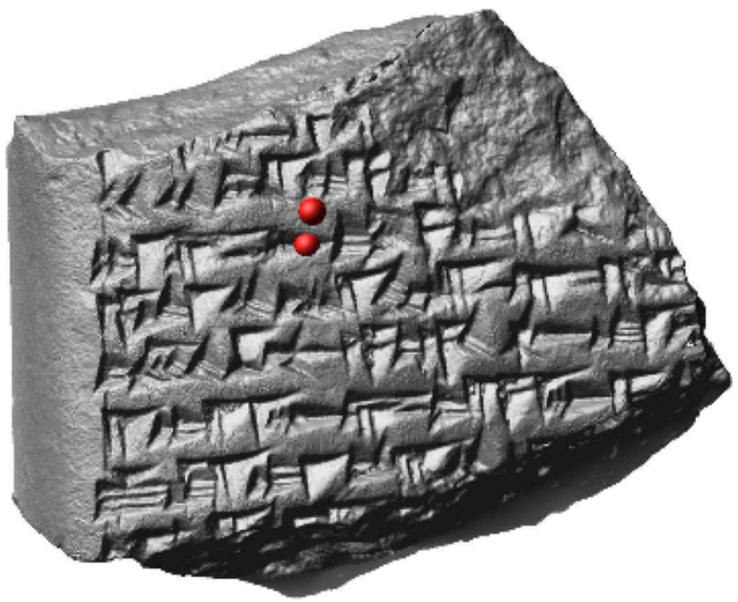
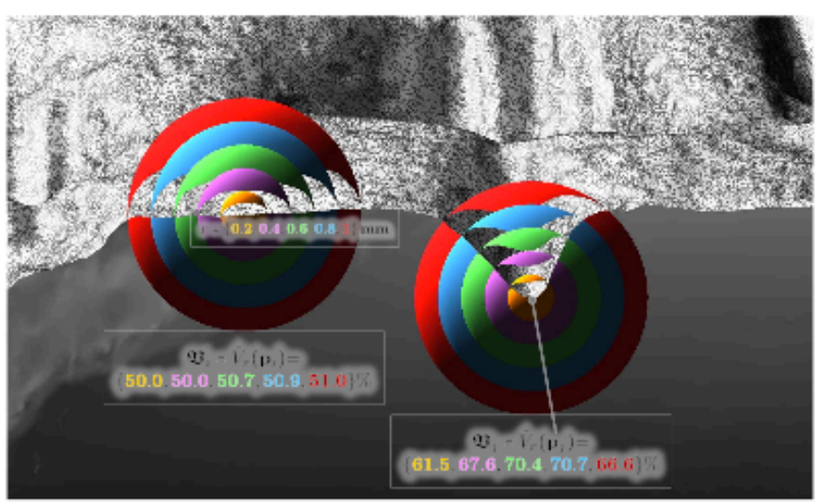
3D scans have the depth sufficient to allow for accurate vectorization of the signs, similar to the scholar's copy



(a)



(b)

Fig. 2. 3D-model of (a) a cuneiform tablet showing two balls used to illustrate the integral invariant filtering. (b) Enhanced detail with the exemplary multi-scale spheres/balls and the corresponding feature vectors.

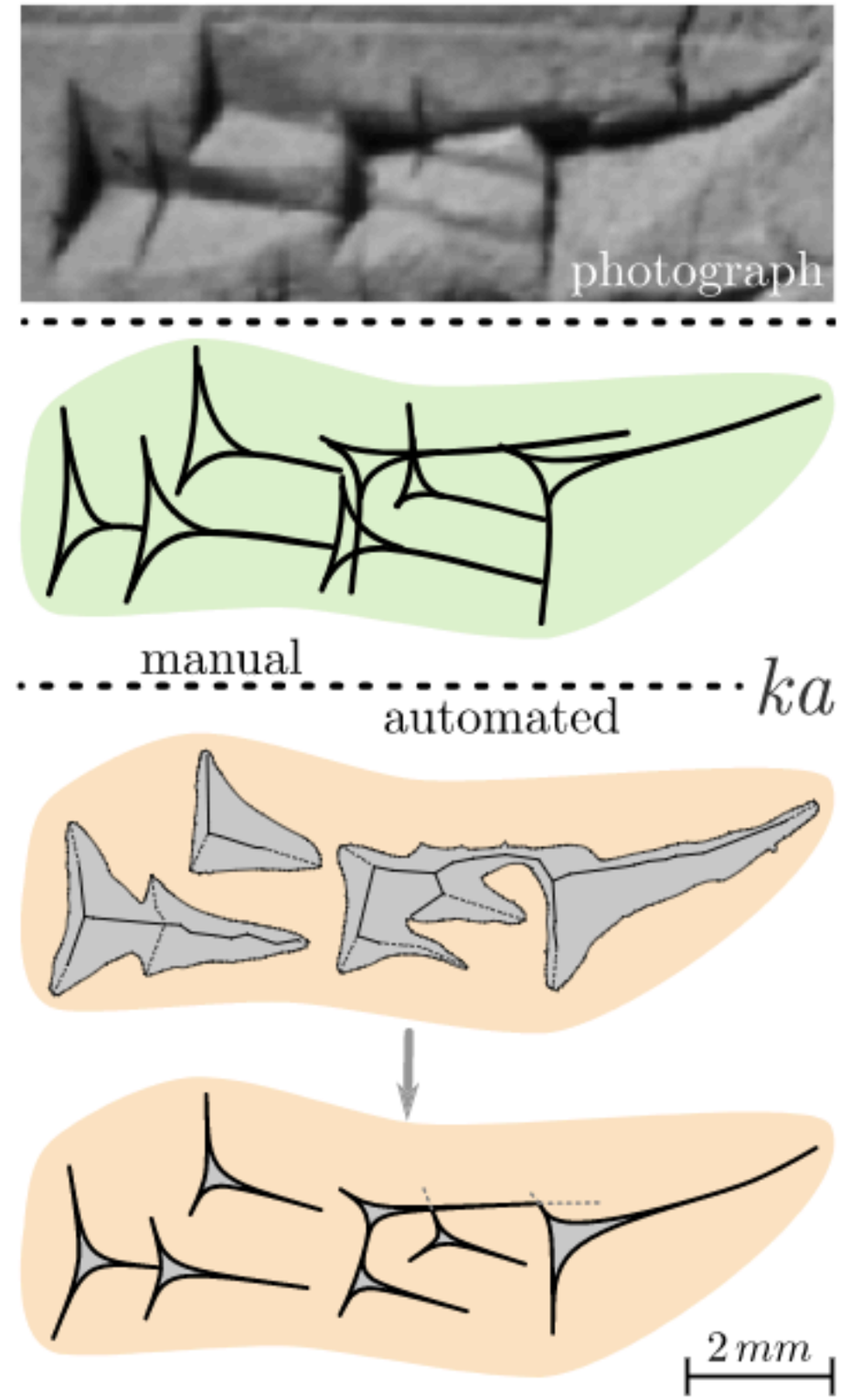


Fig. 7. Comparison of the photograph used for the manual drawing of the character *ka* to the vector drawing computed using a 3D-model of tablet *VAT 10908*.

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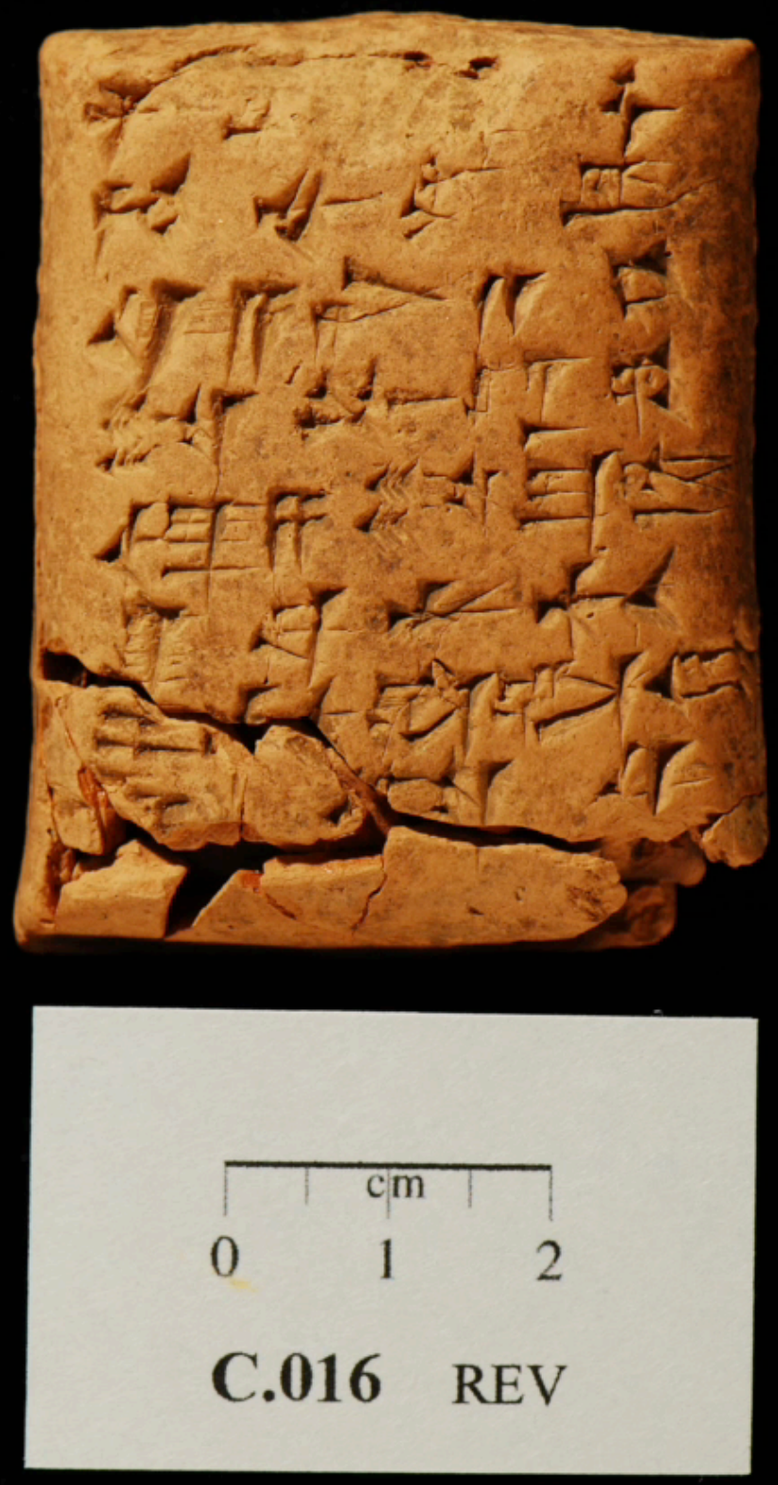

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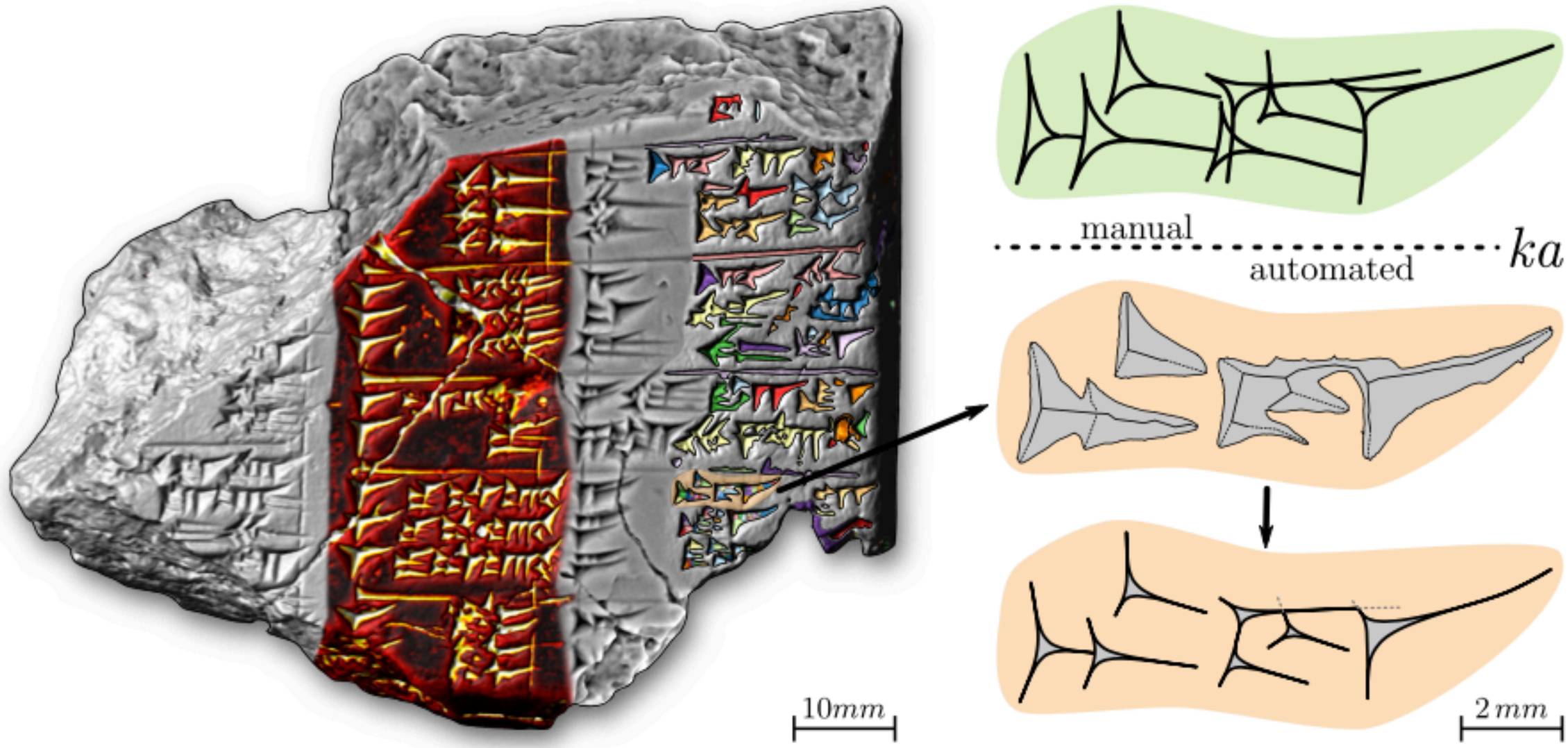

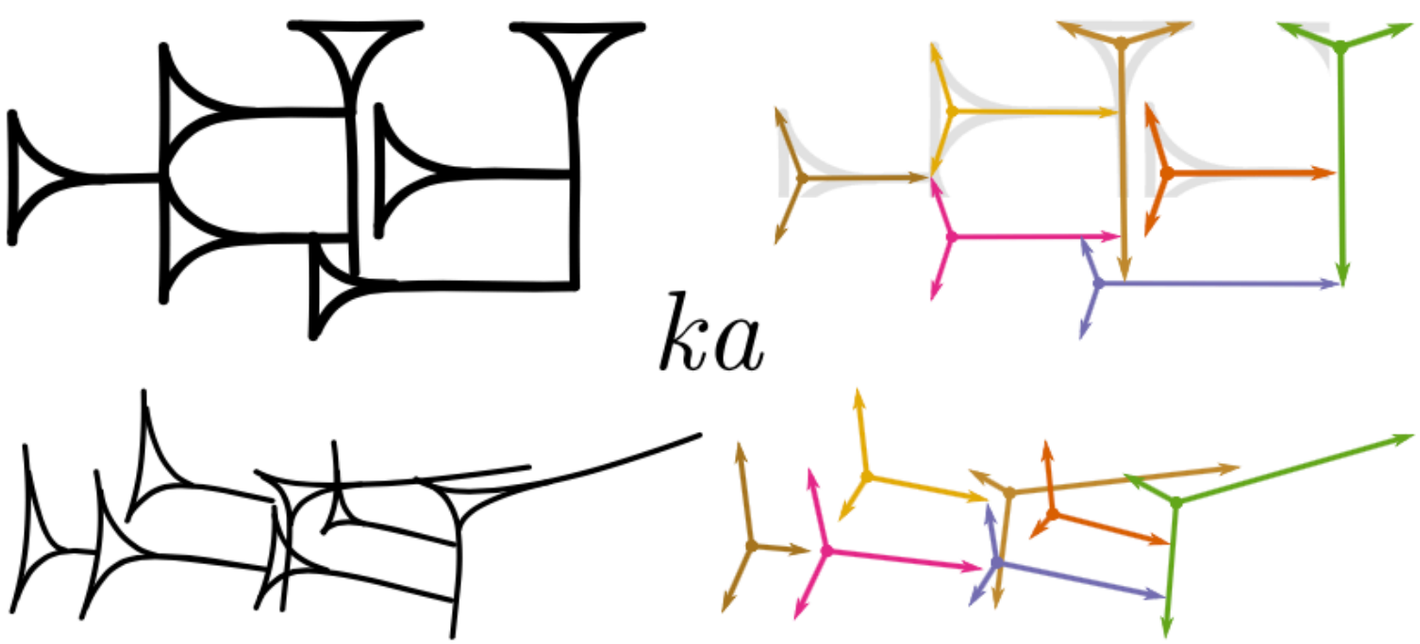

KA
“mouth”

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using an n-dimensional matrix we can represent each glyph and distinguish ligatures

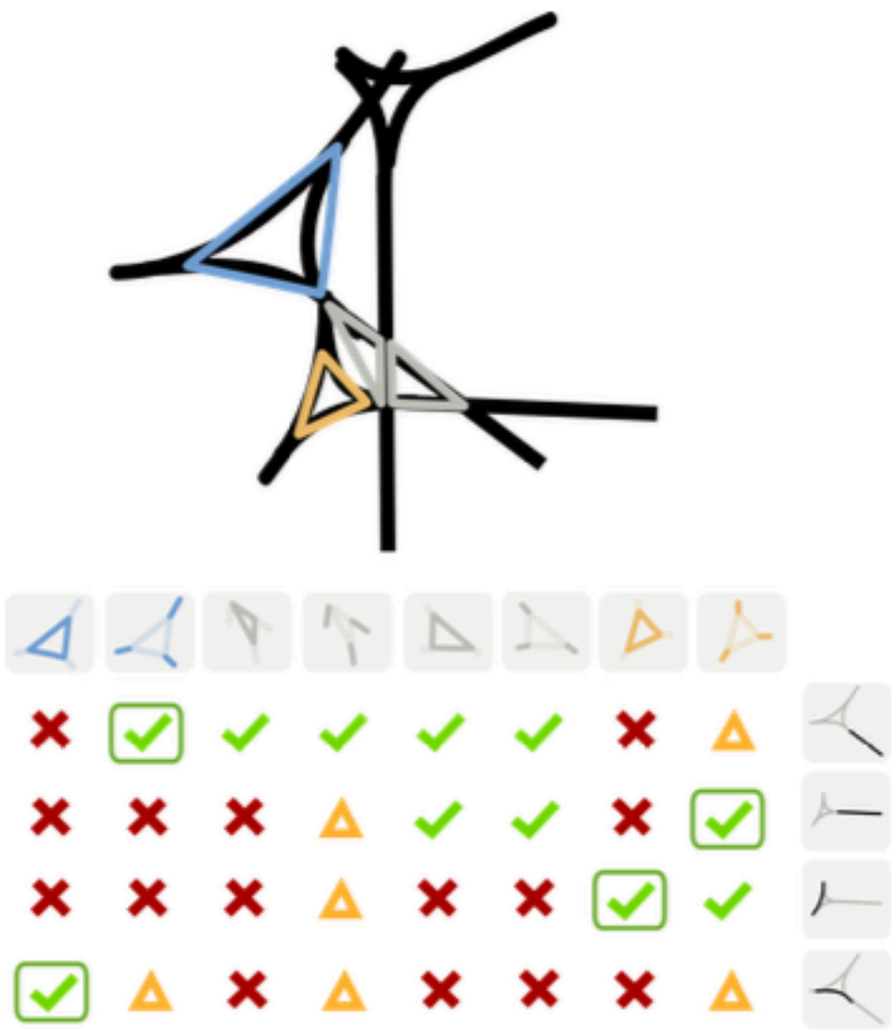

Figure 2. A simplified visual representation of the score matrix used for optimally assigning strokes to wedges. False positive candidate wedges are gray triangles. True positive candidate wedges are orange and blue. The green check mark signifies a match with high score, the orange triangle a match with low score and the red cross a match that is not allowed.

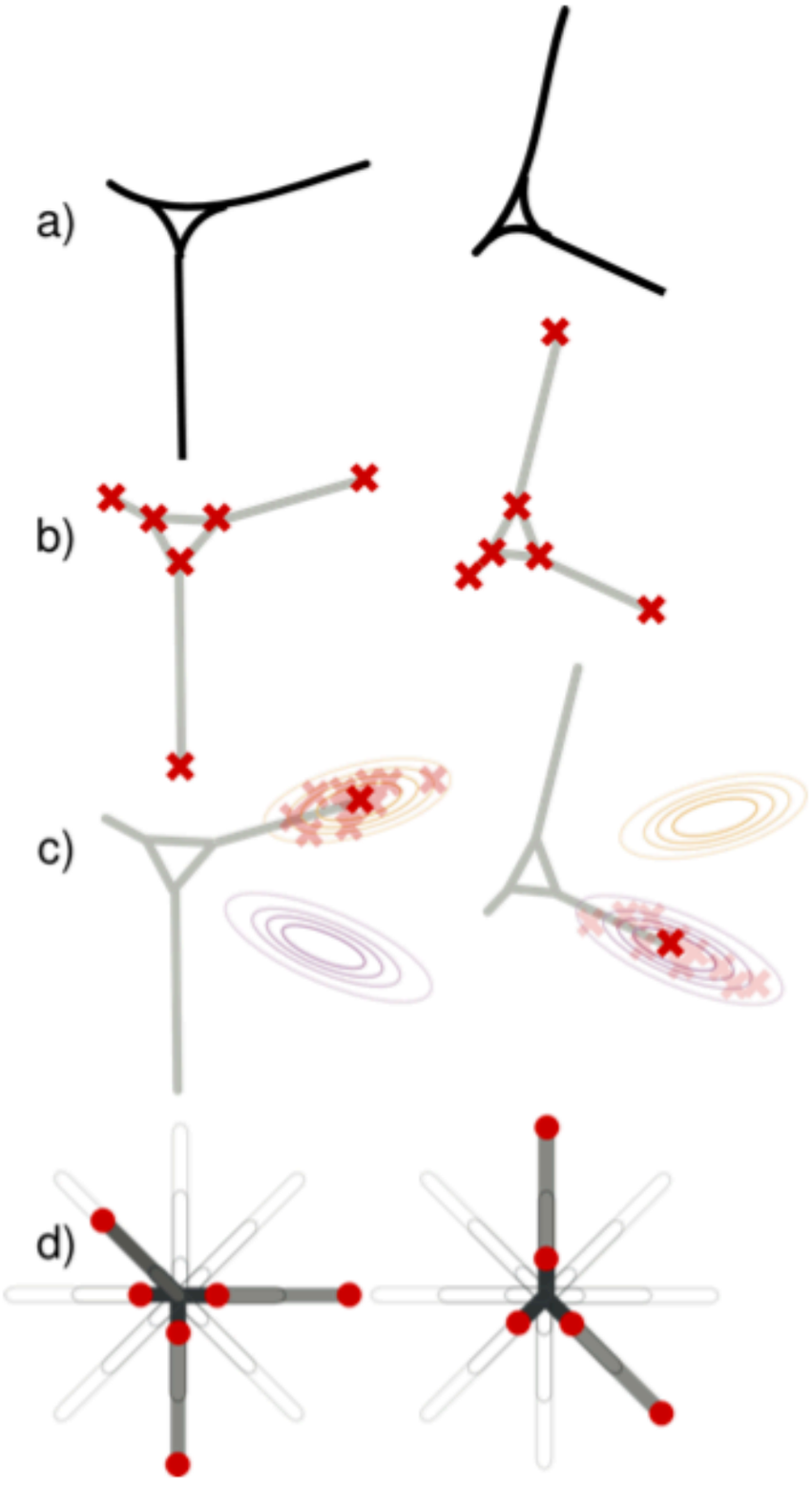

Figure 3. a) The original wedge as present on the cuneiform tablet. b) Keypoints model, each red cross marks one of the six extracted keypoints. c) Gaussian mixture model, contour lines for two Gaussian mixtures for one keypoint are shown. d) Template model, each red dot indicates a bit in the feature vector. The count of set bits varies depending on the shape of each character.

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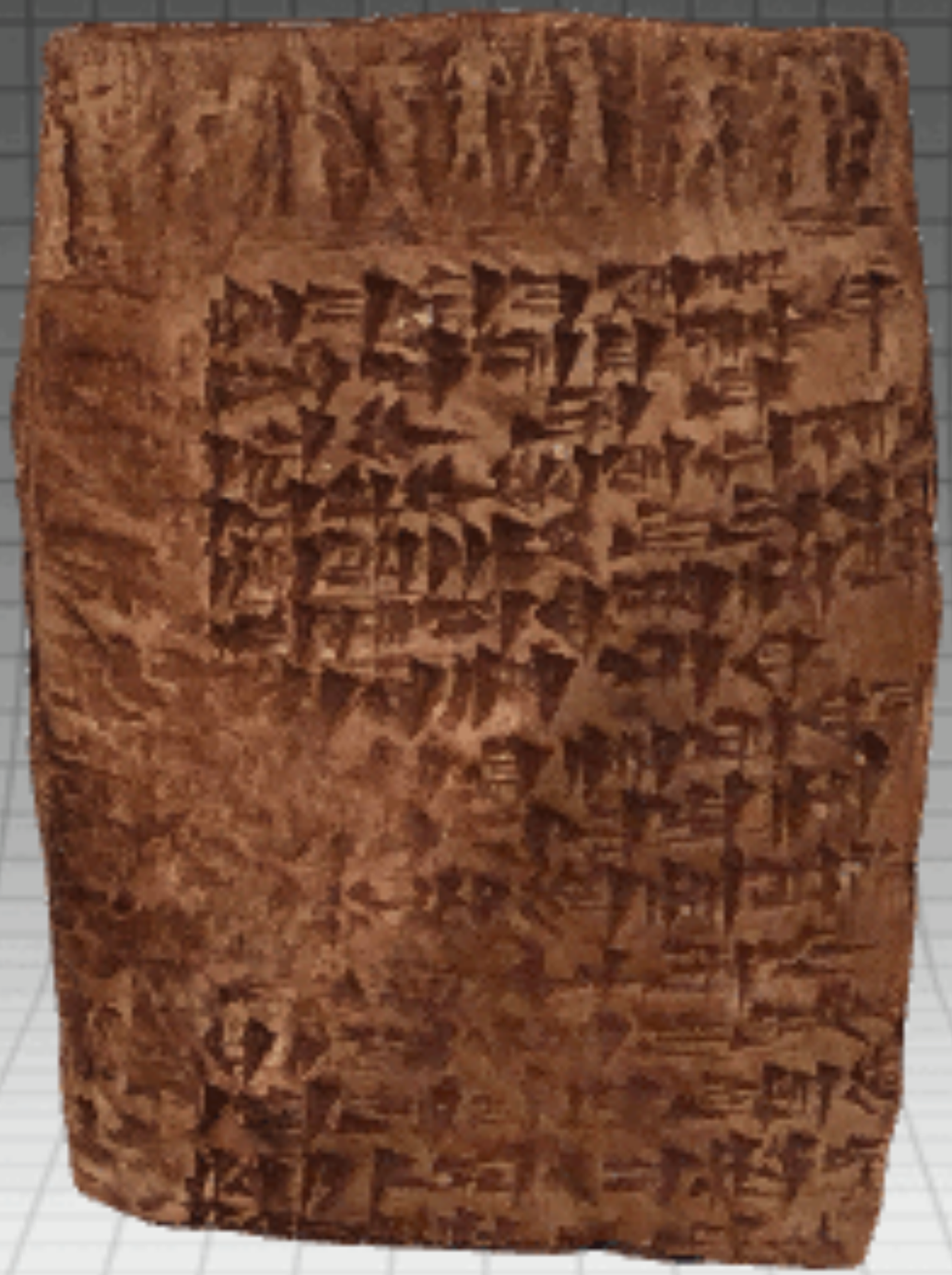
Photogrammetry & 3D Scanning



QLONE

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Kültepe-Kaneš, Turkey

Adam Anderson. 2018. The Old Assyrian Social Network:
an analysis of the archives from Kültepe-Kanesh
(Harvard University Dissertation)

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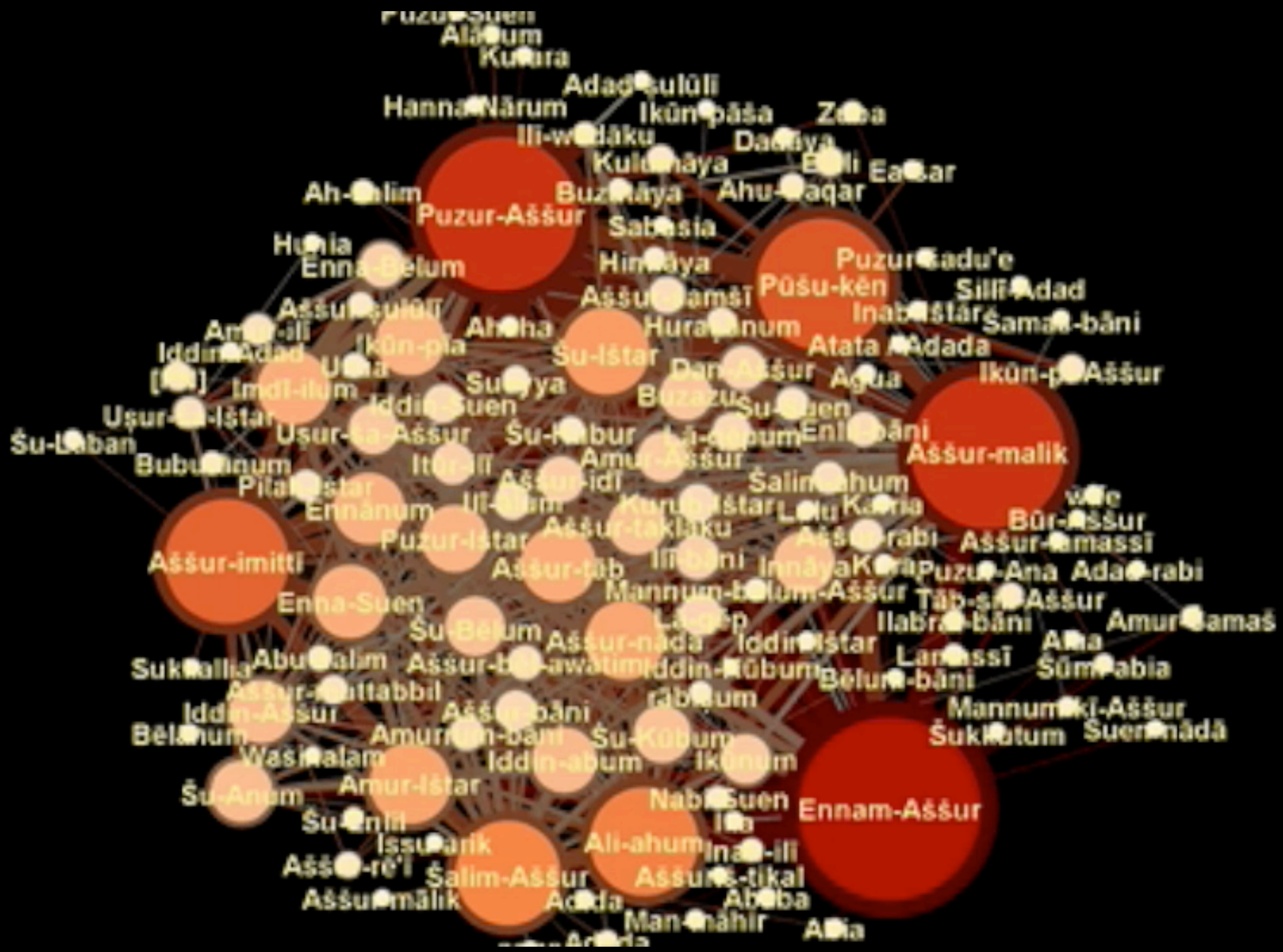
gephi.org



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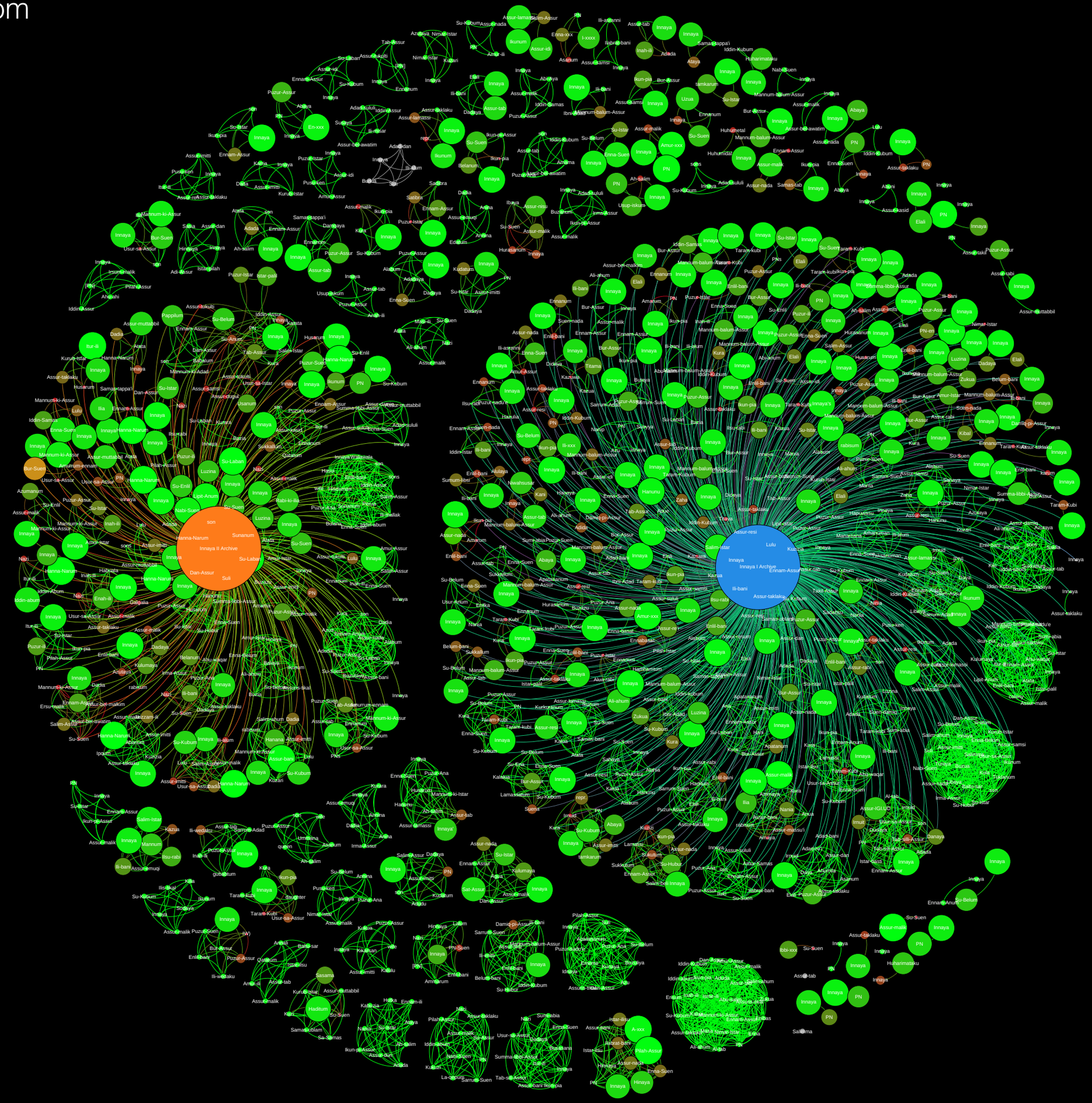
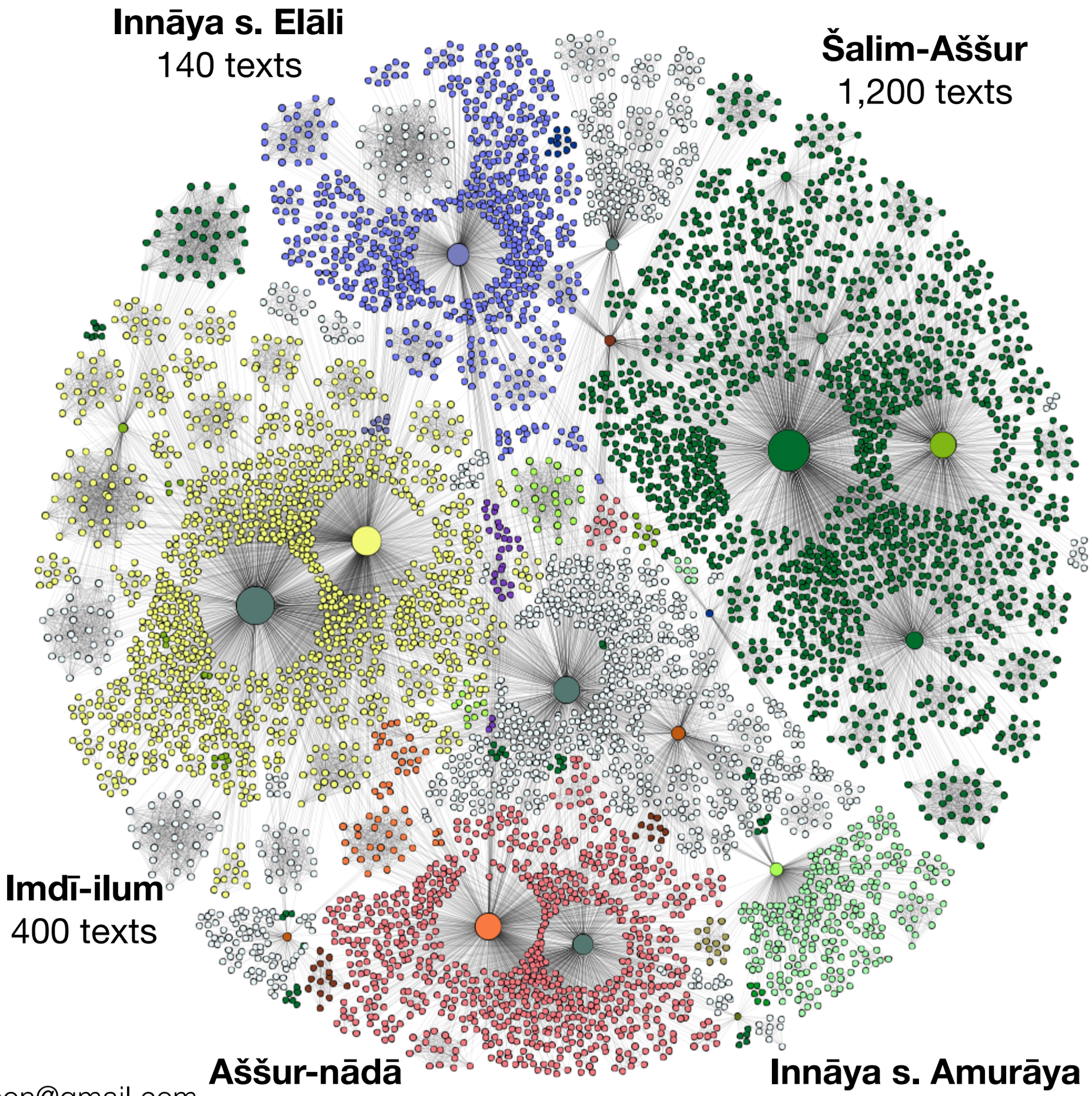
Archives of

Innāya I s. Elāli



Innāya II s. Amurāya

low (1000) Rank & high (1)



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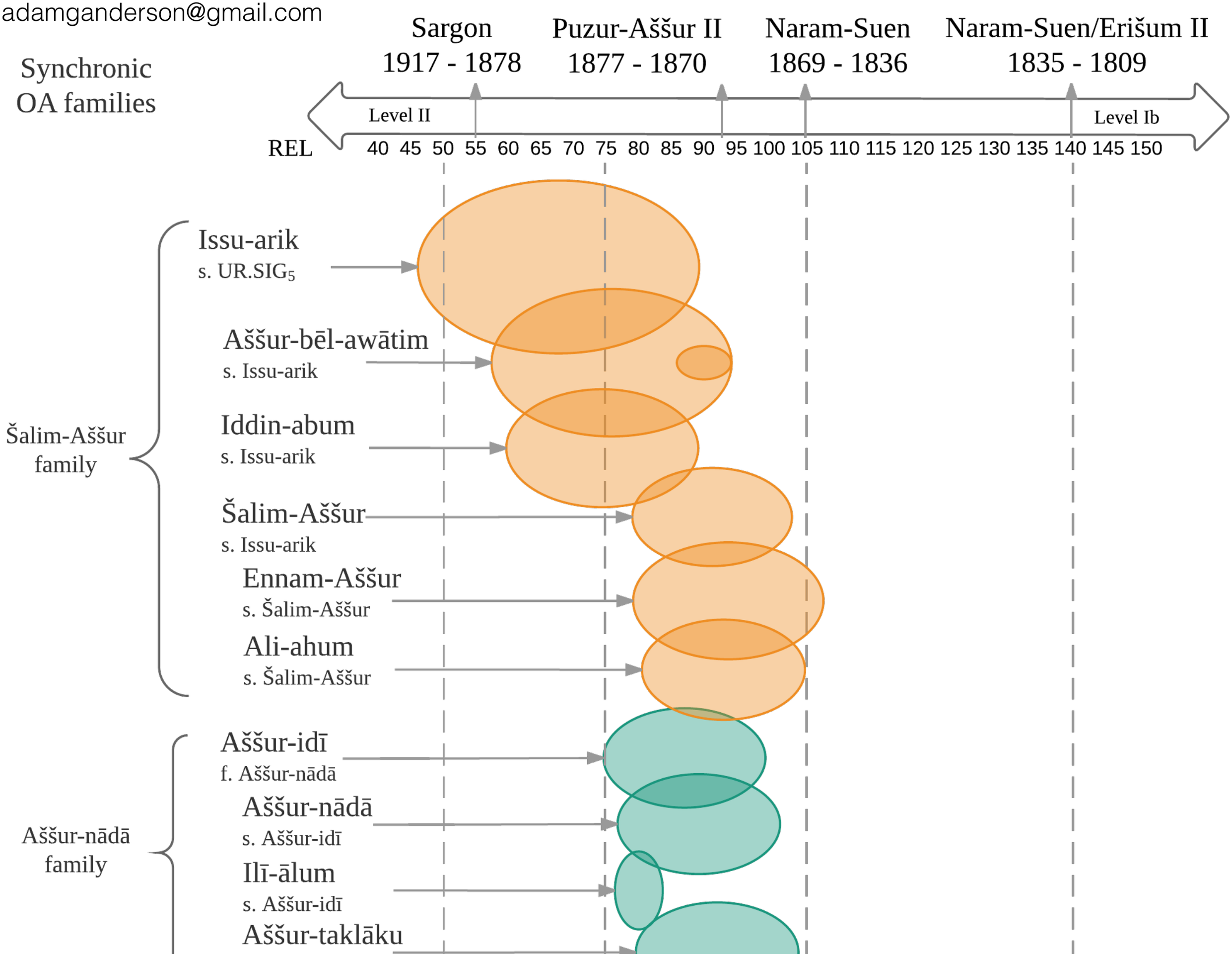

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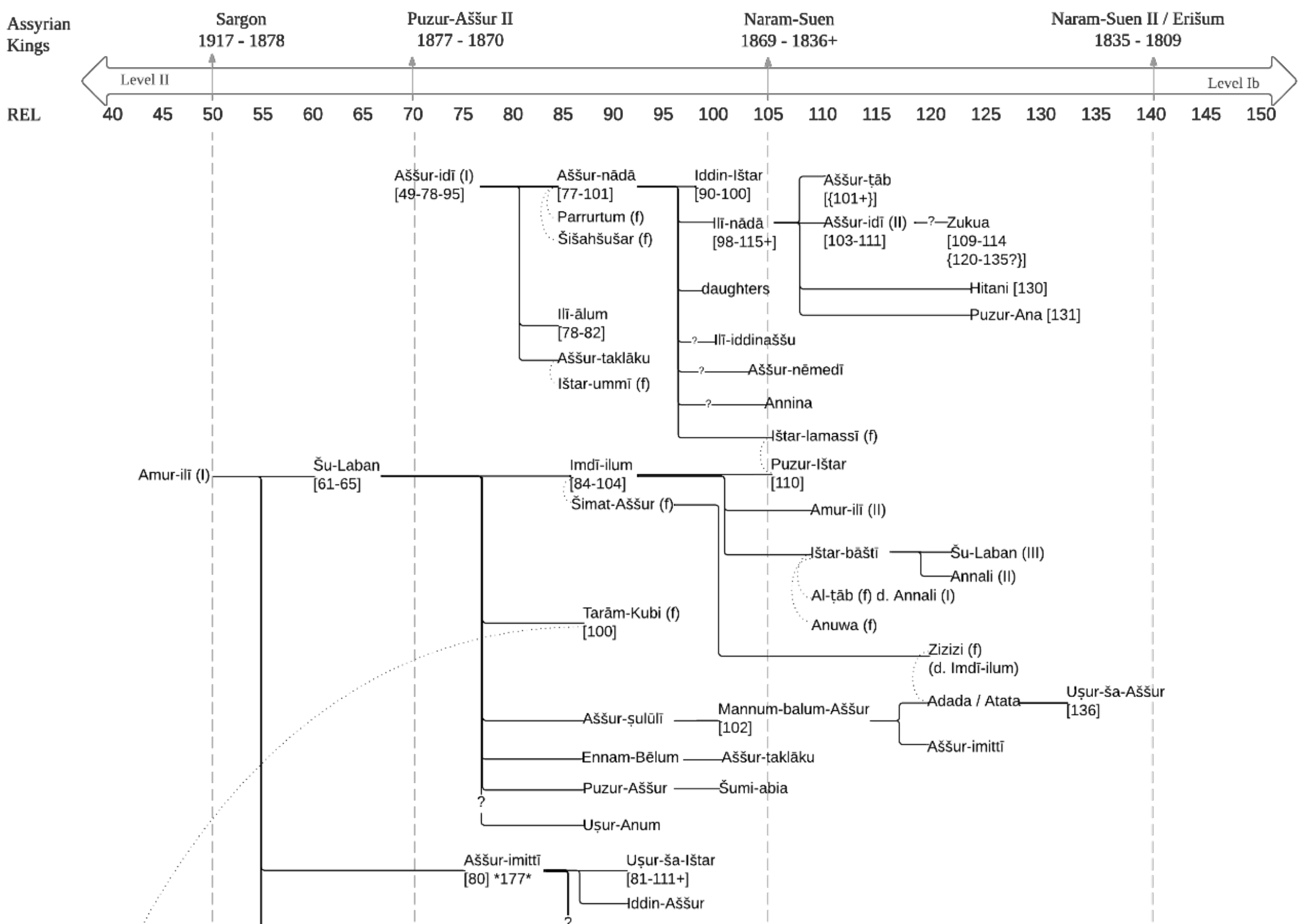

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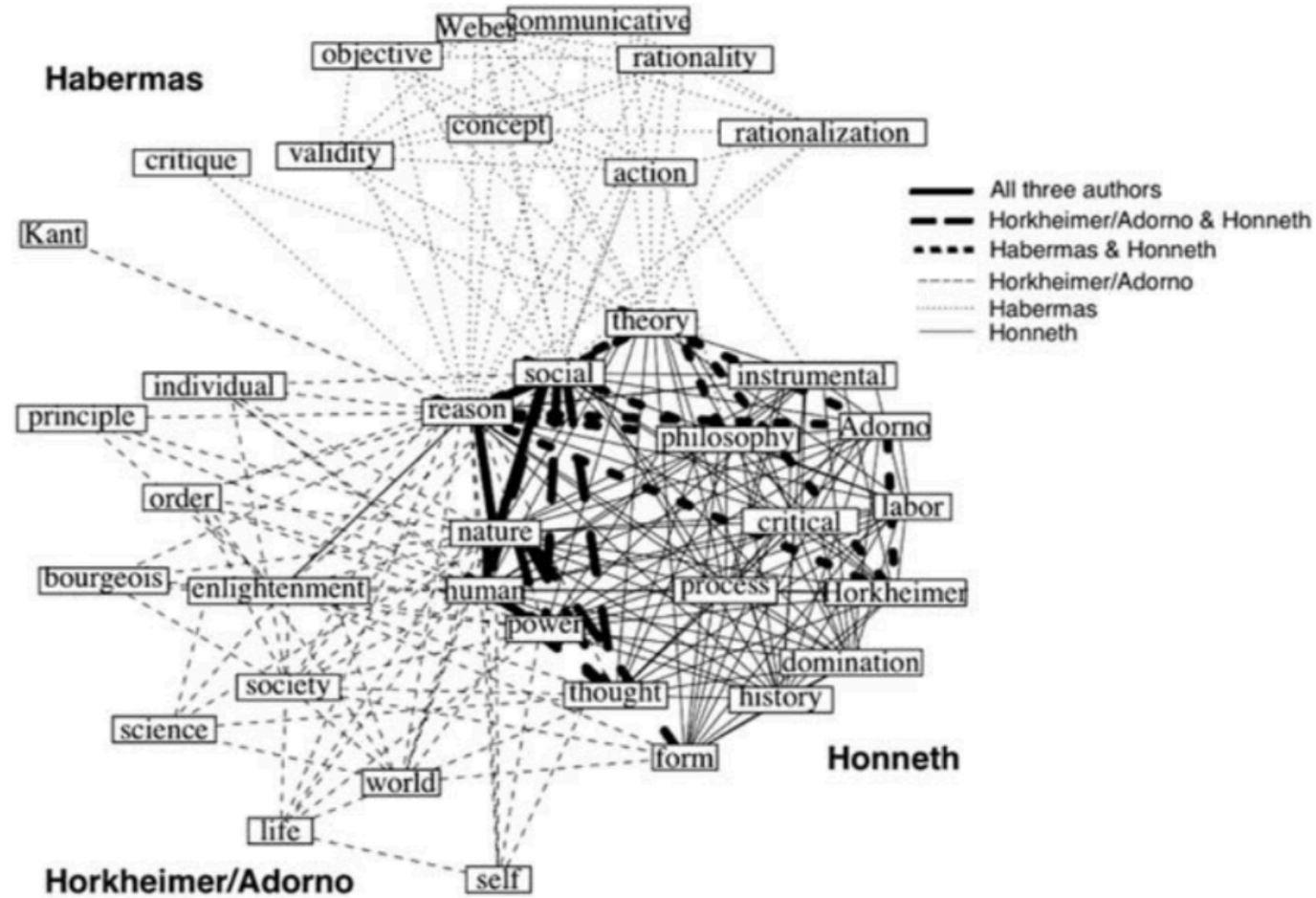
Lee et al. 2014. Coding, Counting and Cultural Cartography.

"Things get exponentially more complex when we consider the *adjacency* of words. That is, we count not just the number of times any word is used, but the number of times two words occur in close succession (such as in the same sentence or paragraph)."



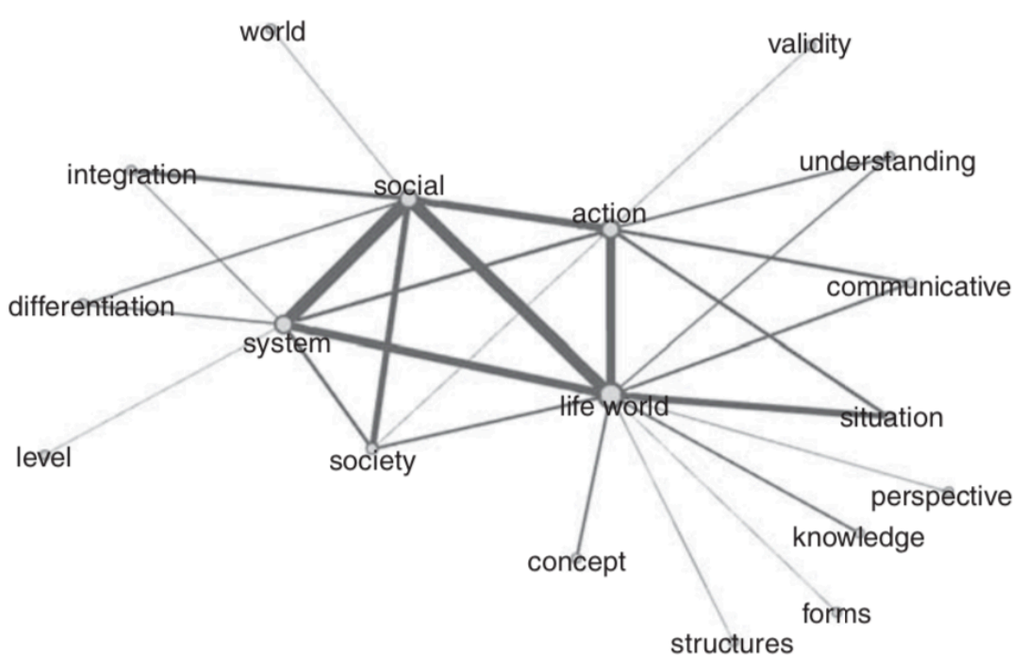
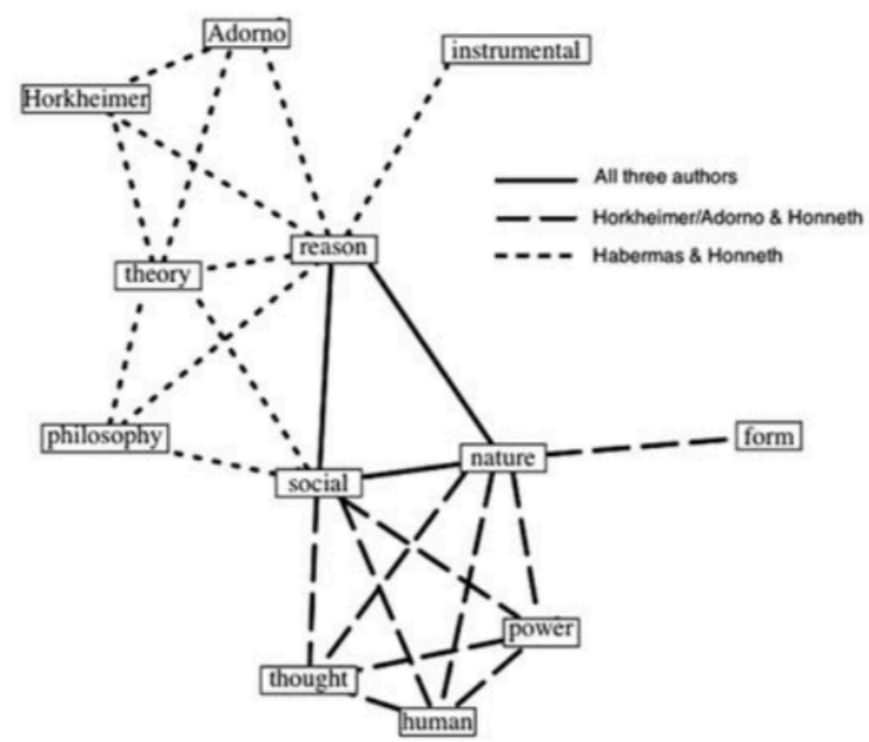


Figure 2: Chapter 6: 'Intermediate Reflections: System and Lifeworld'.



e 3: Overlaps of concept maps of three generations.

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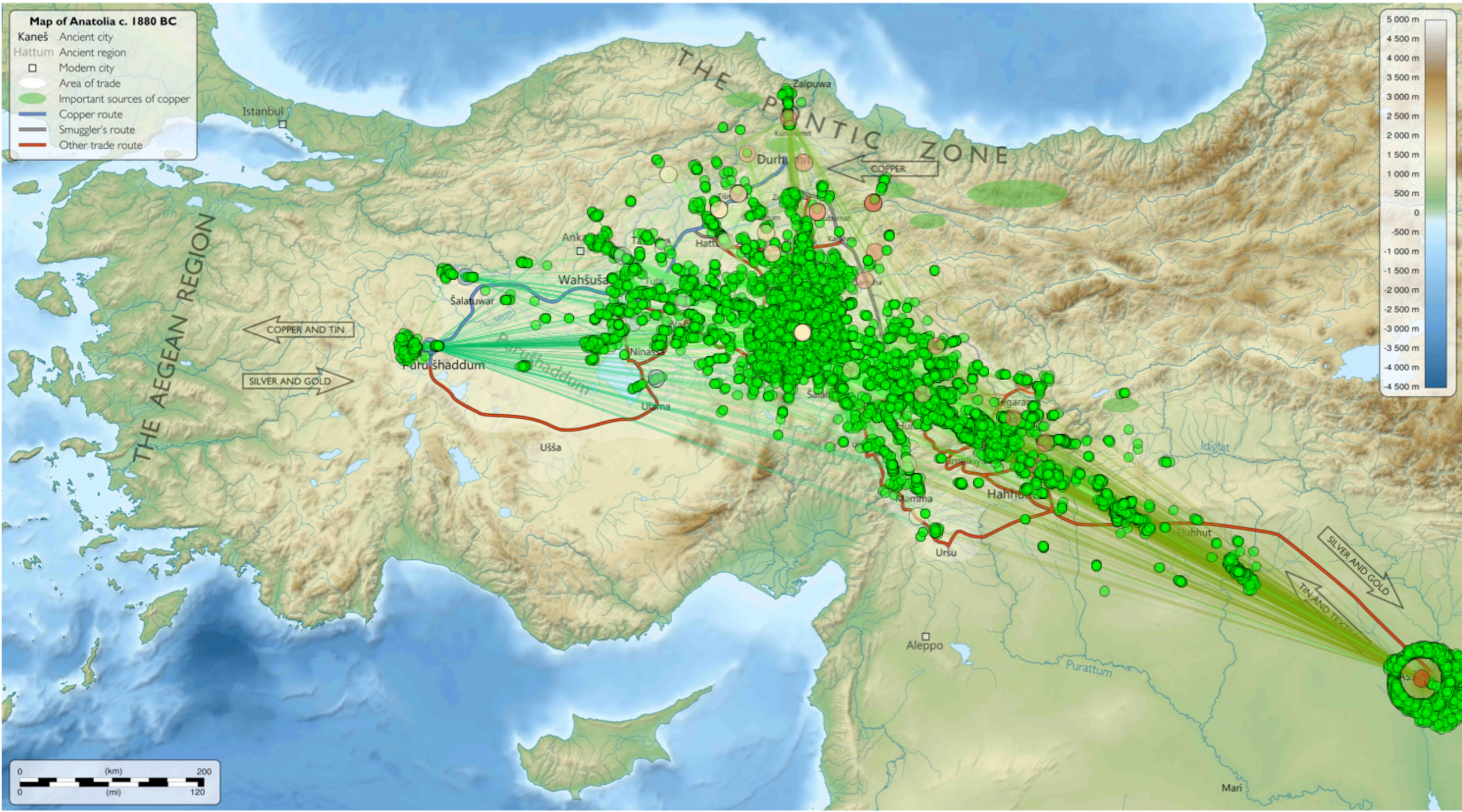
6,000 Tablets
Old Assyrian Archives

1950-1750 BCE

● named entity per tablet



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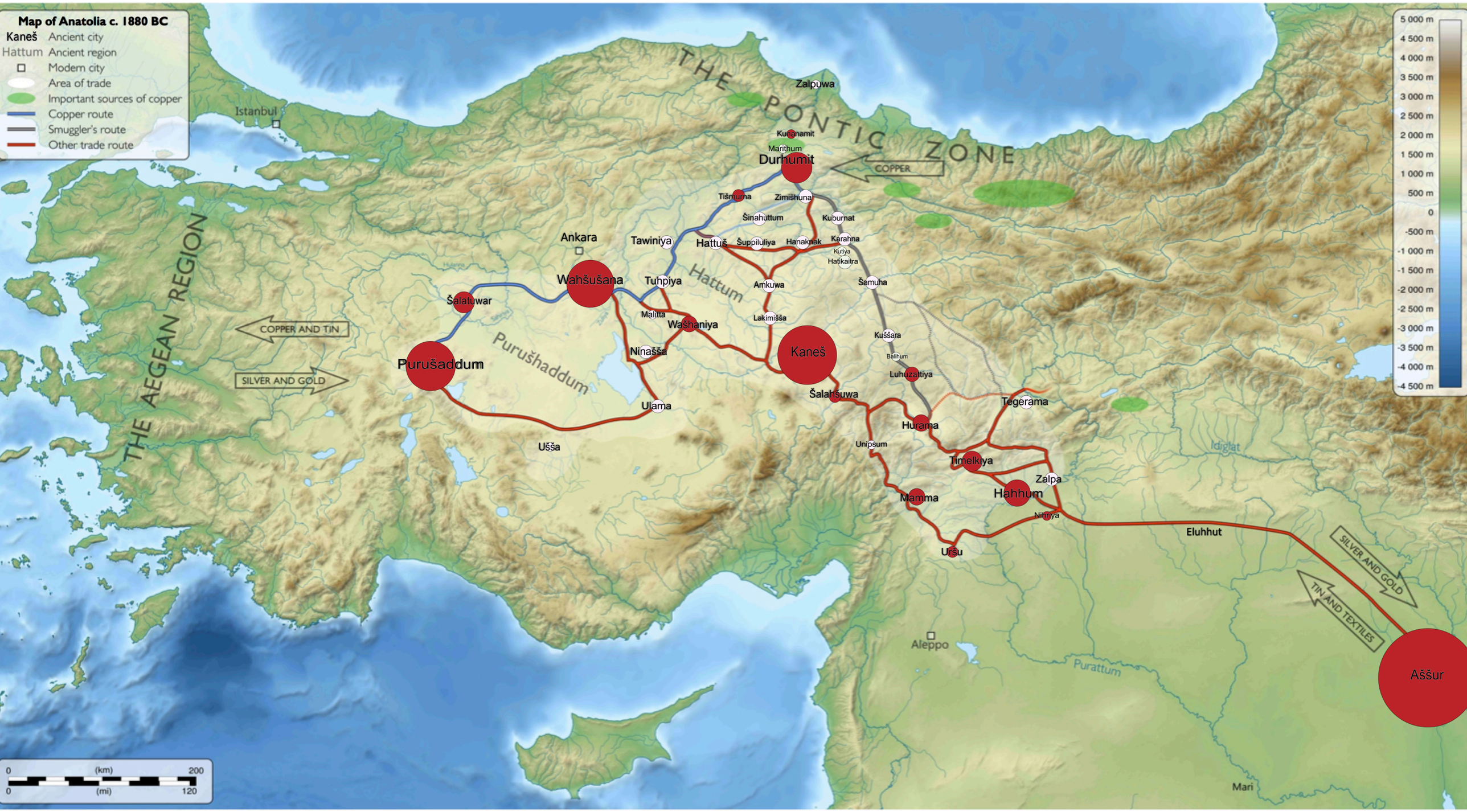
Aššur-nādā's Trade Routes

Aššur-nādā Geospatial Network

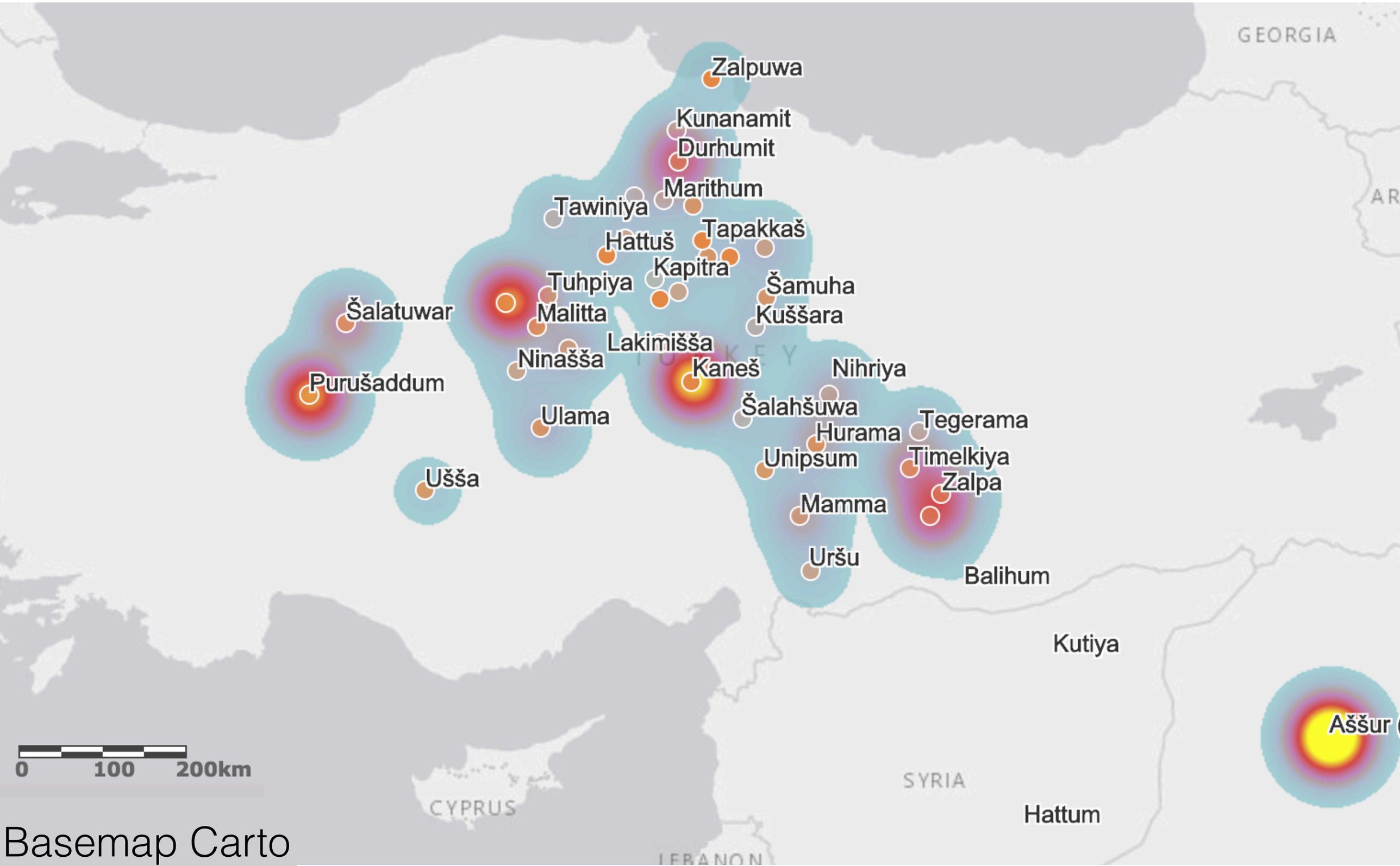


Basemap courtesy Barjamovic 2011

adamganderson@gmail.com

Old Assyrian Archives

1950-1750 BCE



Basemap Carto

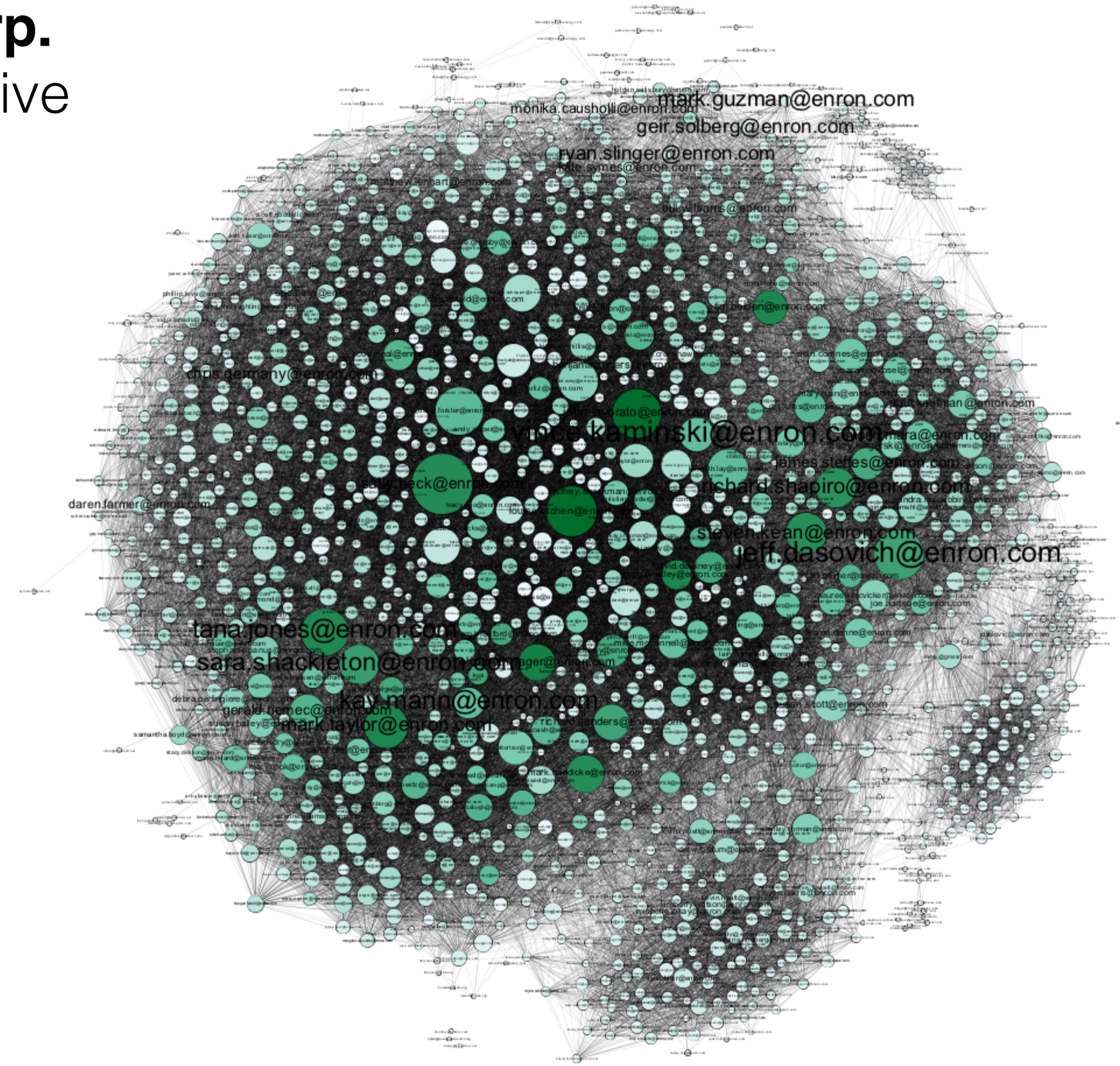
adamganderson@gmail.com

Enron Corp.

Email Archive

85k nodes

350k edges



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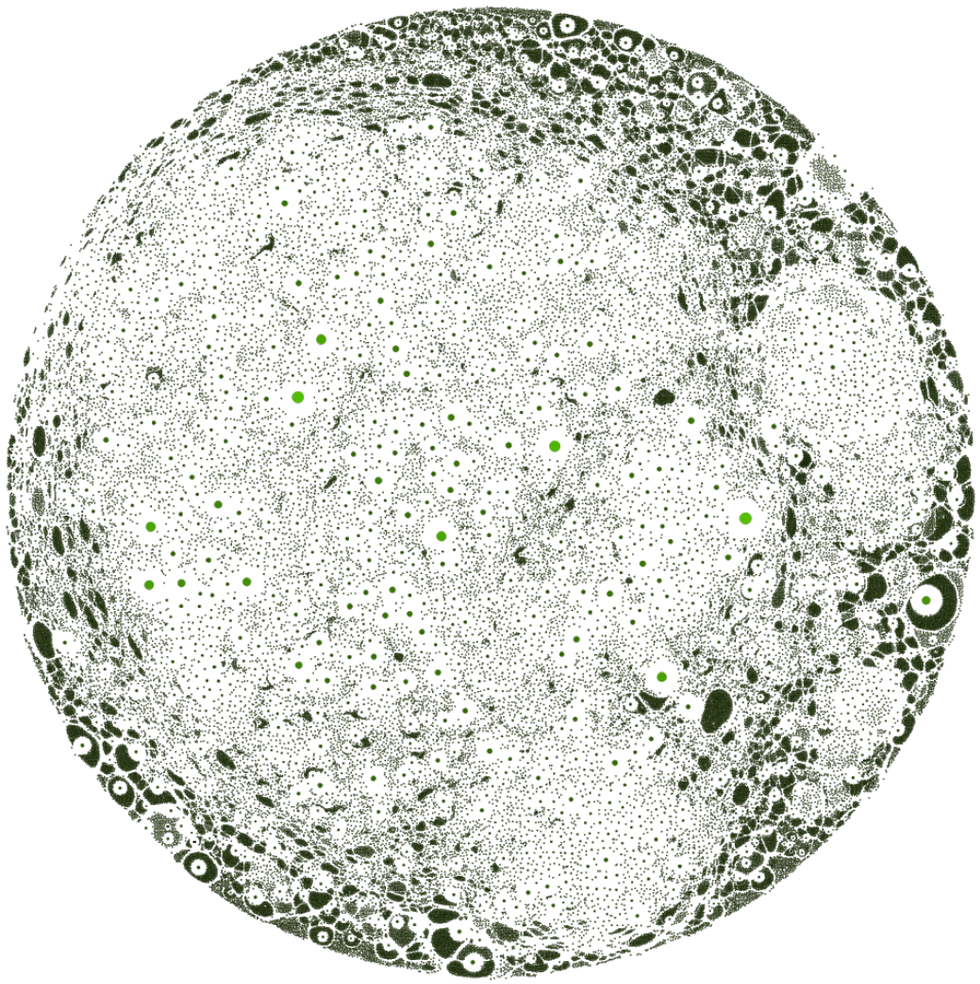
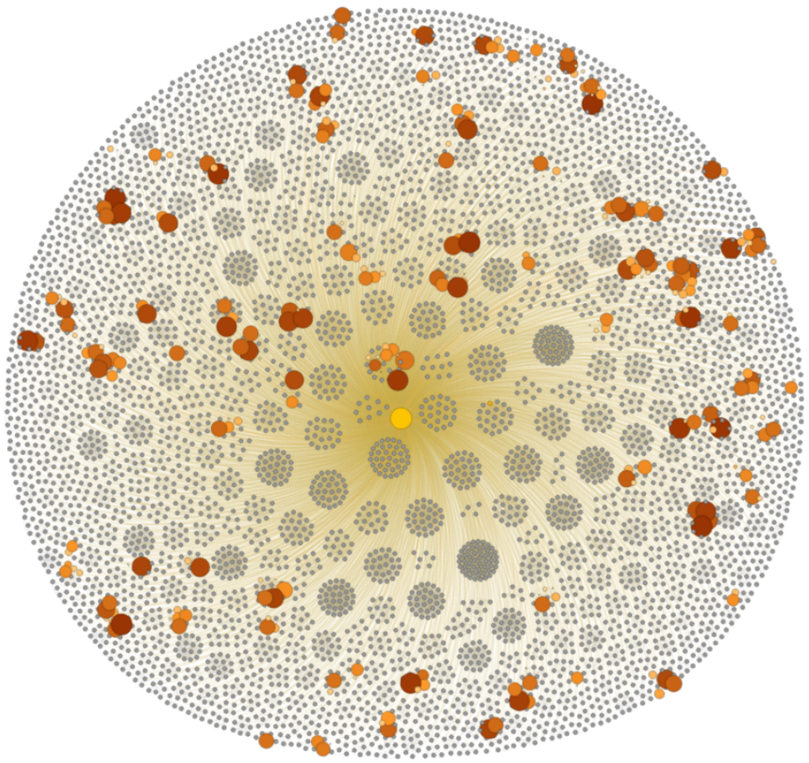
Enron Corp.
Email Archive
1991-2001 ce
500k emails

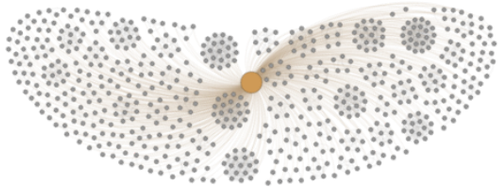


150 employees
20k pop.
85k nodes
350k edges

Old Assyrian
Kaneš Archives
1950-1850 bce
6k tablets



1800-1750 bce



c. 20k pop.?
13k nodes
75k edges

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Adam Anderson
admndrsn

Adam Anderson is a Mellon Postdoctoral Fellow in the Digital Humanities at UC Berkeley.

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Python ★ 1

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Morphological Analyzer for Akkadian

Python

Gephi

Network graphs in Gephi

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